EXPERIMENTAL STUDY OF VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH VARIOUS MASS FLOW RATES

A project report submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING
IN
MECHANICAL ENGINEERING
By

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CERTIFICATE

This is to certify that the Project Report entitled "**EXPERIMENTAL STUDY OF VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH VARIOUS MASS FLOW RATES.**" being submitted by MADIYA LOKANADHAM 314126520202, PAKKI RAVI 314126520198, VASAMSETTI SHARNU KUMAR 314126520164, SUJAN KUMAR YAKASIRI 314126520155, in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING of ANDHRA UNIVERSITY**. It is the work of bona-fide, carried out under the guidance and supervision of **Mr. G. Naresh**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2014-2018.

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ACKNOWLWDGEMENT

We are happy to present this report on "***EXPERIMENTAL STUDY OF VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH VARIOUS MASS FLOW RATES***" in partial fulfilment of the requirement for the award of B.E., Degree in Mechanical Engineering.

We take this opportunity to express our deep and sincere indebtedness to our esteemed guide **Mr.G.NARESH**,Assistant Professor, ANITS, a source of constant motivation in successfully completing our project.

We intend to express our thanks with sincere obedience to **Prof.B.NagaRaju**, Head of Mechanical engineering department and **Prof.T.V.Hanumantha Rao**, Principal for facilitating the execution of this work.

Lastly, we will be grateful to one and all who have contributed either directly or indirectly in completion of the project.

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NOMENCLATURE

Nomenclature:

A surface area of tubes

C specific heat

COP coefficient of performance

h specific enthalpy

mr mass flow rate

M mass

P pressure

Q heat transfer rate

t temperature

U overall heat transfer coefficient

W power consumption of compressor

Subscripts

ac actual

b brine

c condenser

e evaporator

i inlet

isen isentropic

m mean

o outlet

r refrigerant

th theoretical

w water

ABSTRACT

A refrigerator is machine which cool and maintain a body at a temperature below that of surrounding. Majority of refrigerator system works on vapour compression refrigeration system.The performance of vapour compression refrigeration system (VCRS) depends on the performance Of all its components like compressor, condenser, expansion value and evaporator. To Improve the Coefficient of Performance (COP), it is required to decrease the Compressor Work and increase the Refrigerating Effect. Experimental analysis on vapour compression refrigeration (VCR) system with R134A (Tetra Fluro Ethane) refrigerant was done and their results were recorded.

The effects of the main parameters of performance analysis are mass flow rate of refrigerant, suction pressure of compressor, delivery pressure of compressor, temperature of evaporator and condenser. The results from vapour compression refrigerant syatem was taken where the variables like suction pressure of compressor, delivery pressure of compressor, temperature of evaporator and condenser were noted and coefficient of performance (COP) was calculated.

The main objective of this project is to fabricate the vapour compression refrigeration system with R-134a as refrigerant and To study the system by changing the mass flow rate of the refrigerant for one ton of refrigeration at different loads.This project is intended to address challenges faced in the real world and some practical issues. Theoretical and experimental approaches used as a methodology in this work.

LITERATURE REVIEW:

In study of applied thermo dynamics all the while we have been observing heat transfer from a system at higher temperature to that at lower temperature. Now in the study of refrigeration we will be observing various methods of coling the objects and maintaining the temperatures of badies at values lower than surrounding temperature.

According to American society of Heating, Refrigeration and Air-conditiong engineers (ASHARE) " Refrigeration is the science of providing and maintaining temperature below that of the surrounding temperature".

In the olden days around 2500 years B.c Indians, Egyptians. Etc... were producing ice by keeping water in the porous posts open to cold atmosphere during the night period. The evaporation of water in almost cool dry air accompanied with recitative heat transfer in the clear night caused the formation of ice evan when the ambient temperature was above the freezing temperature. Further reference are available which support the use of ice in china 1000 years BC. Nero, the emperor. Was using ice for cooling beverages further.the east Indians were able to produce refrigeration by dissolving salt in water as early as 4^{th} centyry A>D,. Of course , on very small scale the use of evaporative cooling is another application of refrigeration used olden days. The cooling of weater in earthen ports for drinking purpose; is the most common example where the evaporation for water through the pores of earthen pot is accompanied with cooling of water.produce refrigeration by dissolving salt in water as early as 4^{th} century AD,. Of course , on very small scale the use of evaporative cooling is another application of refrigeration used olden days. The cooling of weater in earthen ports for drinking purpose; is the most common example where the evaporation for water through the pores of earthen pot is accompanied with cooling of water.

M.S.Kim *:*

M.S.Kim have experimentally investigated the performance of a heat pump with two azeotropic refrigerant mixtures of R290/R134a and R134a/R600a with the mass fractions of 45%/55% and 80%/20%. The performance parameters of the azeotropes were compared with pure R12, R134a, R290 and R22 at the both heating and cooling conditions with suction-liquid heat exchanger. The COP of R134a/R290 was lower than that of R22 and R290, and R600a/R134a shows higher COP than R12 and R134a. The capacity for R134a/R290a was higher than that for R290 and R22, and R600a/R134a exhibits higher system capacity than R12 and R134a. Experimental results show that the compressor discharge temperatures of the considered azeotropic mixtures are lesser than those of the pure refrigerants i.e., R22 and R12.

H.M.Hughes:

H.M.Hughes have addressed the issues by blending the components of zeotropic mixtures and subsequent packing. Assessment was carried out with the blend of R32, R125 and R134a with the mass fraction of 23%, 25% and 52% respectively. He focused on the issues related to blending equipment and techniques, the number and quantity of components and the temperature of the blend. While preparing the blends in the cylinder, introduce the individual components of the mixture serially starting with the lowest vapour pressure component and progressing to the highest.

1 INDEX

2 INTRODUCTION

The present project is based on Vapour Compression refrigeration. The cooling unit i .e. condenser is primary component on which the whole project is based upon. The project is carried out in 4 steps. Firstly the parameter of existing air cooled condenser measured such as pressure, temperature, power consumption etc. For measuring the above parameter pressure gauge temperature gauge wattmeter and refrigerant chart is used. Then we have changed the cooling medium of existing condensing unit i .e. from air to water. Because the heat transfer coefficient of water is almost 4 times the air. For this we have made a air tight casing in which the existing condenser is place and water is circulated and then parameter are measured such as pressure, temperature. In this cooled water is supplied at the inlet and hot water extracted from the outlet due to which the refrigerant is sub cooled to a lower temperature before entering the expansion valve in the condense itself by rejecting heat to the cooling medium due to which there is small increases the C.O.P. of refrigerator. After this we have changed the existing condenser with newly designed condenser which is designed with optimal parameters and then parameters are measured such as pressure, temperature .and a considerable amount of increase in C.O.P.is observed due to considerable reduction in compressor work. Then again we changed the cooling medium of condenser to water and due to this a considerable amount of increase in the C.O.P. is observed due to increase in refrigeration effect along with decreases in compressor work. And the mass flow rate of the refrigerant of Ton of refrigeration is also reduced due to increases in refrigeration effect. Hence it the size of the condenser and evaporator can be reduced witch result in reduction in overall cost of the system.

2.1 Introduction to refrigeration:

"Refrigeration is the science of providing and maintaining temperature below that of surrounding ambient temperature". The term 'maintain' implies, the continuous extraction removal of heat from a body which is already at lower temperature than its surroundings.

Refrigeration is the process of removing heat from a space or substance to reduce and maintain temperature lower than its surrounding. Before the advent of mechanical refrigeration the natural phenomena was used produce and maintain a lower temperature in a space or product. The value of ice as a preservative was known and put to use thousands of years ago. Natural ice from lakes and rivers was often cut during the winter and stored in saw dust insulated buildings, and can be used as required. In the Middle East and India water was cooled by evaporating it through porous clay pots. In favourable conditions it could be made cold enough to form ice.

The early machines the air system was probably the most successful until the development of vapour compression and absorption system using ammonia as refrigerant. In 1859 Ferdinand carre devised vapour absorption system. And ammonia –water cyclel still used in absorption type domestic refrigerators .Thomas Midgely and his associates Henne and McNary discovered dichlorodiflluoro methane, CCL_2F_2(Freon-12 which was) confirmed as super refrigerant with low –level of toxicity and non-flammable.

The vapour compression system is the most widely used refrigeration system in practice. This refrigeration system adopts the vapour compression cycle. This cycle requires the addition of external work for its operation.

Basically itconsists of four processes namely:

1).Isentropic compression

2).Constant pressure heat rejection

3).Isenthalpic expansion

4).Constant pressure heat addition

Vapour compression cycle is an improved type of air refrigeration cycle in which a suitable working substance, termed as refrigerant, is used. The refrigerant used, does not leave the system, but is circulated throughout the system alternately condensing and evaporating.

2.2 Principle of Refrigeration:

Refrigeration is defined as the production of temperature lower than those of the surrounding and maintain the lower temperature within the boundary of a given space. The effect has been accomplished by non cyclic processes such as the melting of ice (o)r sublimation of solid carbon dioxide . However, refrigeration effect is usually produced by transferring heat from a low temperature source to a high temperature source by spending mechanical work. To produce this effect requires certain machinery , hence, the method is called mechanical refrigeration. The working media of such machines are called refrigerants.

2.3 Definition of refrigeration:

Refrigeration is the process of removing heat from substance or space to reduce its temperature and transferring that heat to another substance or Refrigeration is providing and maintaining the temperature below that of the surrounding temperature.

2.4 Unit of refrigeration:

The capacity of a Refrigeration unit is expressed in terms of Ton. One ton of refrigeration is equivalent to the rate of heat transferred needed to produce 1000Kg of ice at 0 water in 24 hours.

One ton of refrigeration= 55 kcal/min=210kj/min or 3.5 Kw.

A refrigerant is the substance used for heat transfer in a refrigeration system. It absorbs heat (latent heat and sensible heat) from the source at a low temperature and pressure and gives up this heat at a high temperature and pressure. The refrigerant which transfer heat in the form of latent heat is more efficient than the air refrigerant which transfer heat in the form of sensible heat. The refrigerant in the first group continuously change its phase from liquid to vapour and vapour to liquid.

However in the second group, the refrigerant exist in the gaseous phase only. The refrigerant which absorb heat in the form of latent heat are more suitable and widely used in the refrigeration system. In selecting a refrigerant for a particular purpose its characteristic must be considered and the selection must be made on the of its compatibility with the system.

Secondary refrigerants are those which are cooled first by the primary refrigerants and then employed for cooling purposes. Indirect method of cooling is produced by absorption of sensible heat.

2.5 Ton of refrigeration:

The refrigeration capacity by of refrigeration is its cooling capacity or heat transfer rate that it can provide forcooling. The SI unit for the heat transfer rate is kW, however, the refrigeration capacity is still measured inTon of Refrigeration (TR)".One ton of refrigeration is equivalent to 3.5kW, and i.e. the heat is removed from thesubstance to produce cooling effect.

2.6 Coefficient of performance of refrigeration:

Coefficient of perfoemance of refrigerator has been defined as the ration of the amount refrigeration effect to the work of compression.

COP=refrigeration effect/compression work

2.7 Classification of Refrigerators:

Refrigeration implies the cooling of a system. It may be obtained by adopting the following methods:

1. Natural methods.
2. Artificial or mechanical methods

Mechanical refrigerators found wide industrial applications. They may be further classified as

2.7.1 Air refrigerators

2.7.1.1 Reversed carnot cycle

2.7.1.2 Bell coleman cycle

2.8 Vapour refrigerators.

2.8.1 Vapour compression refrigerator

2.8.2 Vapour absorption refrigerator

2.9 Methods of Refrigeration:

The refrigeration effect may be produced by bringing the substance to be cooled in direct or indirect contact with cooling medium such as ice. The common methods of refrigeration are as follows.

2.9.1 Ice refrigeration

2.9.2 Dry Ice refrigeration

2.9.3 Air expansion Refrigeration

2.9.4 Evaporative refrigeration

2.9.5 Gas throttling refrigeration

2.9.6 Steam jet refrigeration

2.9.7 Liquid gas refrigeration

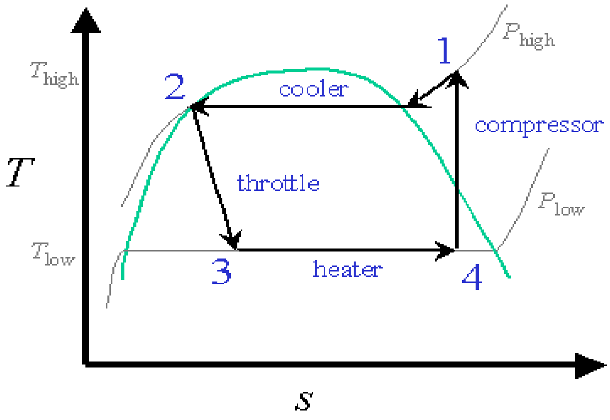
2.9.8 Vapour compression refrigeration

2.9.9 Vapour absorption refrigeration.

2.10 Vapour compression refrigeration system:

2.10.1 Principle :

The ability of a substance to change from a liquid to a vapour under certain pressure and temperature conditions is physical phenomenon called refrigeration cycle.In order for substance to boil from liquid to a vapour or gas, it must absorb heat ; in the absorption of the heat ,the vapourising substance cools the material, whether it be air or water from which the heat is absorbed.

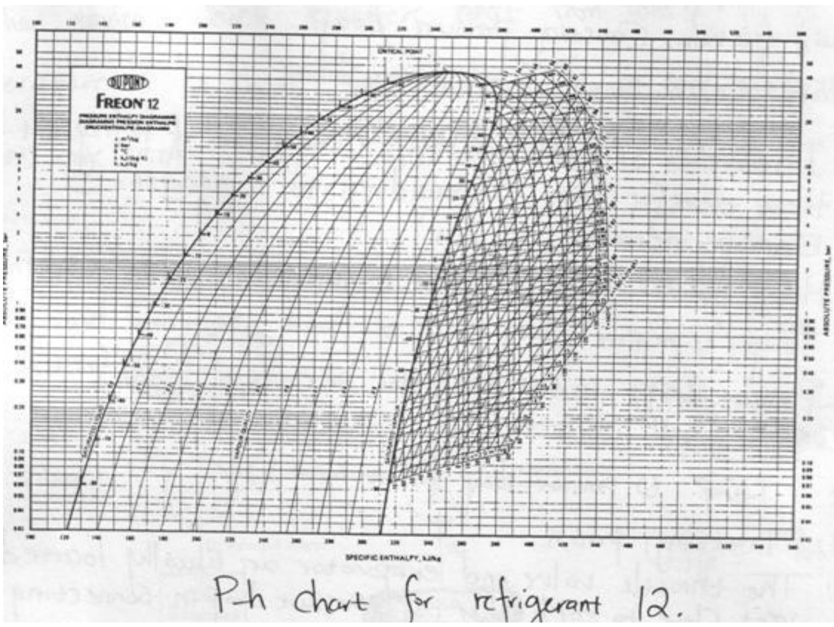


Vapour Compression Cycle

2.10.2 Pressure entyhalpy chart:

The actual vapor compression cycle differ from the theoretical vapor compression cycle in many ways, some of which are unavoidable and cause losses. The main deviations between the theoretical cycle and actual cycle are as follows:

1. The vapour fefigerant leaving the evaporator is an superheated state.
2. The compression of refrigeration is neither isentropic nor polytropic.
3. The liquid refrigerant before entering the expansion valve is sub- cooled in the condenser.The pressure drops in the evaporator and condenser.

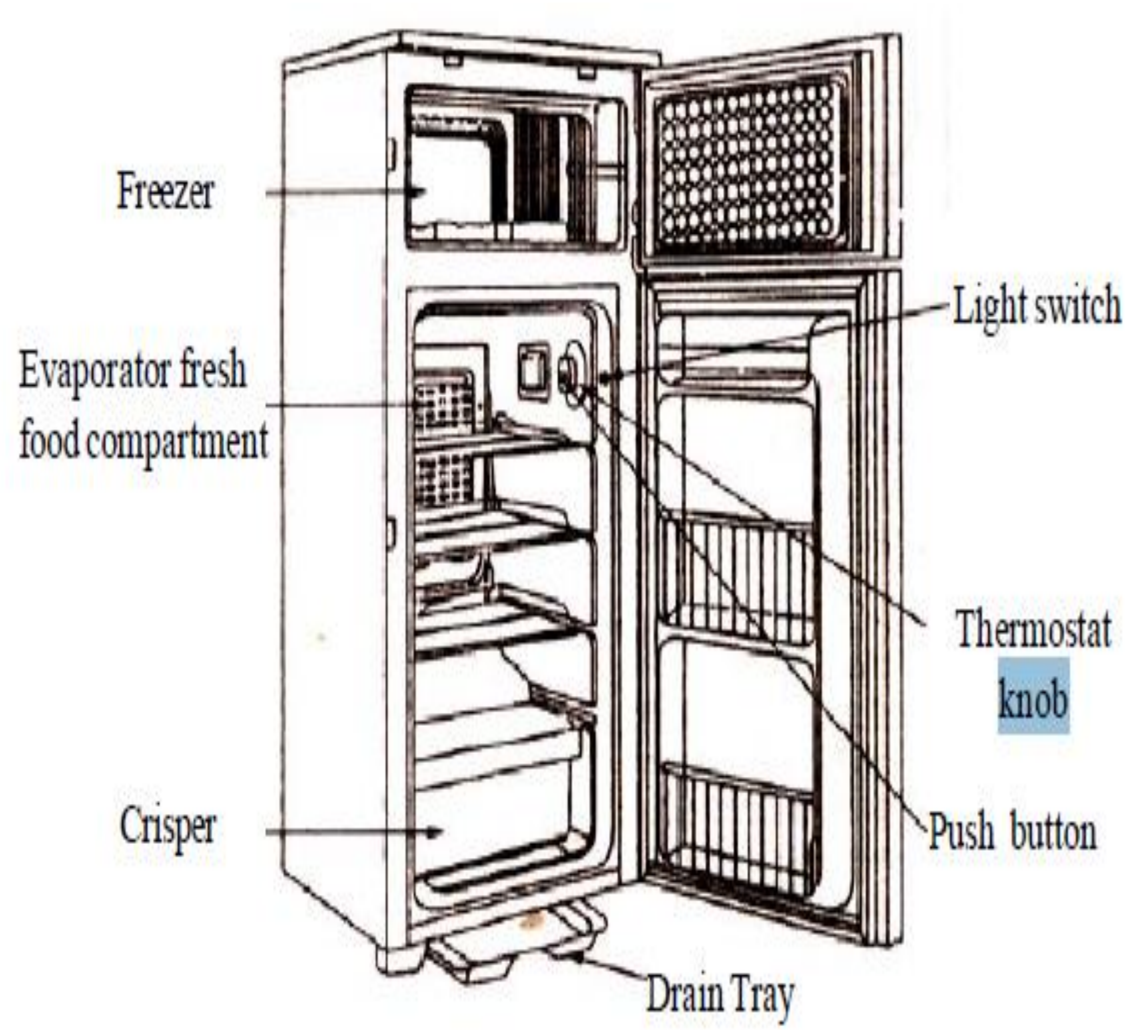


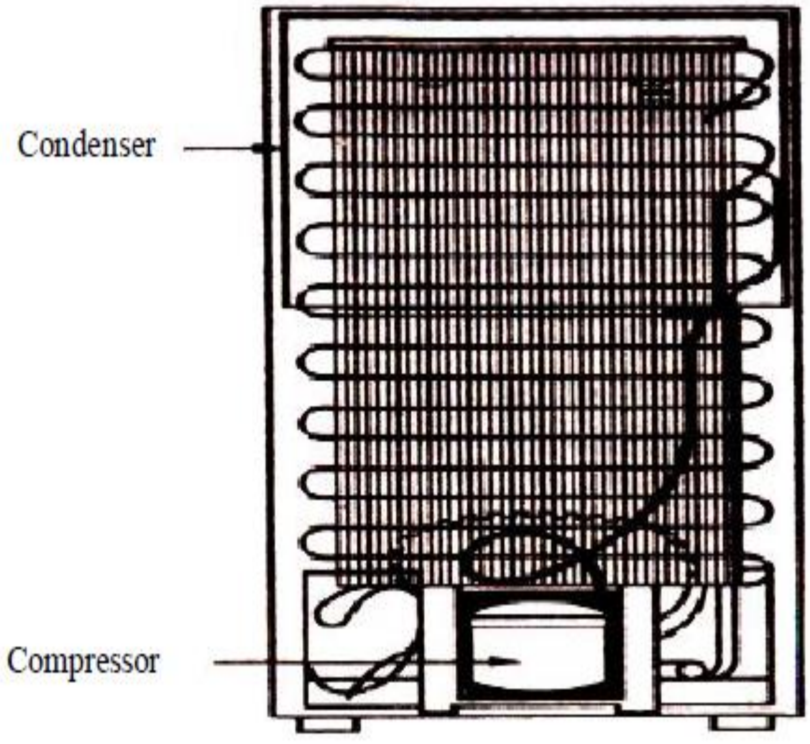
p-h diagram

2.10.3 Domestic Refrigerator:

The domestic refrigerator works on vapour compression cycle. It is compact and more efficient in use of electric energy. The refrigerant used in this is Freon 12. Its main function is to provide low temperature space for the preservation of food. The domestic Refrigerators also used in medical shops, hospitals, hotels, offices, laboratories etc.

The domestic refrigerators capacity is the internal volume of the unit and is expressed in litres. The various common sizes of refrigerators available are 100,165,200 and 300 litres.





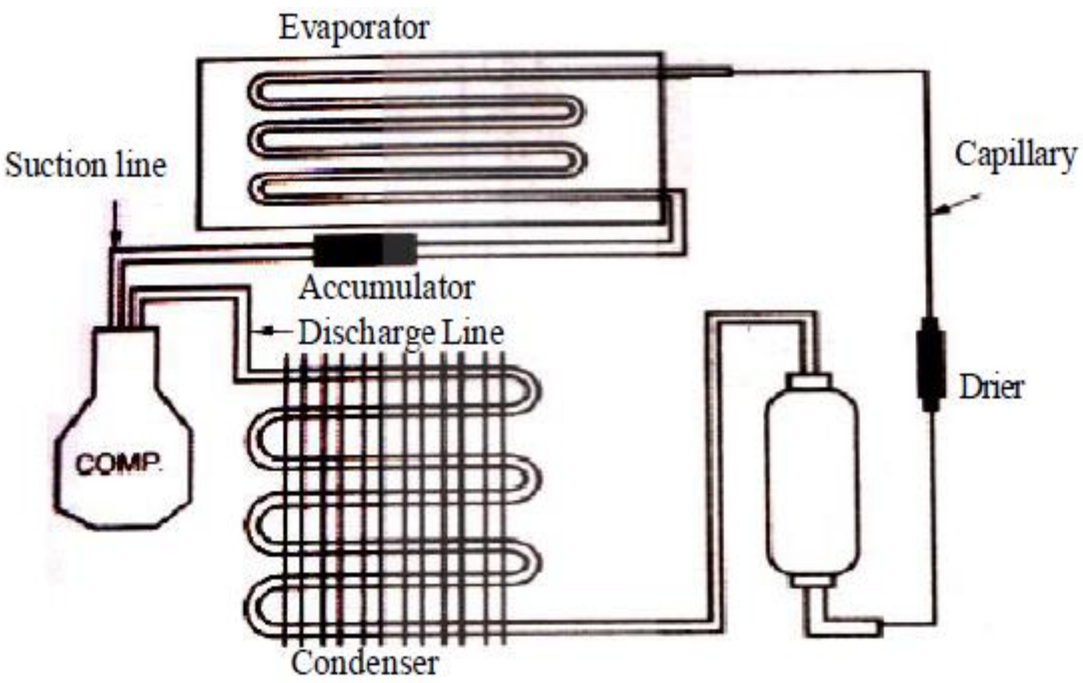
2.11 Components:

The main components of a domestic refrigerator are;

2.11.1 Compressor
2.11.2 Air-Cooled condens
2.11.3 Receiver
2.11.4 Drier
2.11.5 Evaporator
2.11.6 Accumulator
2.11.7 Capillary tube**.**

The refrigerant vapour drawn from the evaporator is compressed in compressor and deliver to the condenser. It is then expanded in capillary tube and passed on to the evaporator. Capillary tubes is used as throttling device is used to reduce the pressure of the refrigerant. The low pressure refrigerant evaporates as absorbing its latent heat and thus producing refrigerating effect in the evaporator.

It consists a hermetically sealed compressor fitted at the base of the cabinet. Condenser is air cooled coil. The evaporator is placed at the top of inside cabinet. The evaporator produce low temperature about -15C and temperature around 7 to 10C can be maintained in the refrigerating space Heavy cold air from freezer moves down wards and becomes warm air after cooling the products. This warm air moves upward. Thus the air movement is maintained continuously in the refrigerated space. The freezer is a mini cold storage in which ice-cubes , ice-creams , frozen foods, meat poultry and fish can be preserved. A thermostat is provided to control the temperature in the freezer. Chiller tray is provided below the freezer to prevent the accumulation of water drops in the freezer. Below the freezer, it consists adjustable shelves to preserve fruits, vegetables, cooked foodEtc. Egg tray, dairy bins ,bottle shelves are provided in side the door of refrigerator. It should be placed in a clean and well ventilated area and kept on the leveled place. It is important to check the functioning of thermostat, door switch, light etc., and a separate plug must be provided for the refrigerator.



The various functions of the components of domestic refrigerator are:

1.11.1 Compresser:

In this, rotary type compressor is used and is sealed unit. It compresses the refrigerant gas to high pressure and temperature .

1.11.2 Evaporator:

The evaporator cools the air in its surrounding in the cabinet. The cold air being heavier moves downwards to cool the food stuff and becomes warm. This warm air being lighter moves upward to take the place of cold air. The convection currents are formed in the cabinet which enable the maintain of uniform temperature.

1.9.3. Drier :

A drier is connected between the receiver and the evaporator to eliminate the traces of moisture, if any.

1.9.4. Accumulator :

It is connected between the evaporator and compressor, which accumulates liquid droplets of the refrigerant and prevent the compressor from any possible damage.

1.9.5. Capillary Tube:

The throttling device is a capillary tube. In this, the pressure equalizes through out the system during off- cycle, and hence a low starting torque motor can be used.

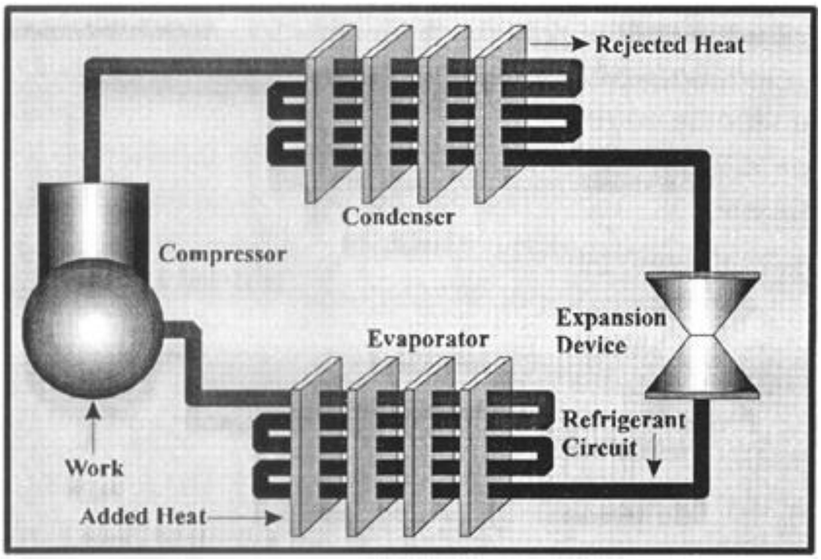
2.12 Main Processes involved in the VCRS system:

1.10.1. Compression

1.10.2. Condensation

1.10.3. Expansion

1.10.4. Evaporation



Vapour compression refrigeration system(VCRS)

2.12.1 Compression :

The low pressure vapour refrigerant in dry state is drawn from the evaporator during the suction stroke of the compressor. During compression stroke pressure and temperature of the refrigerant increases.

2.12.2 Condensation :

The high pressure and high temperature vapour refrigerant enters in to the condenser through the discharge line . Heat will be rejected in to the cooling medium and the refrigerant change its state from vapour to liquid.

2.12.3 Expansion

After condenser, the liquid refrigerant is stored in the liquid receiver until it passes through expansion valve. The function of the expansion is to allow the liquid refrigerant under controlled pressure in to the low pressure path of the system.

2.12.4 Evaporation

The low pressure liquid refrigerant after expansion in the expansion device enters the Evaporator or Refrigerated space and absorbs its heat. Due to this heat, the refrigerant changes its state from liquid to vapour and then sucked back by the compressor during its suction stroke . The cycle is repeated till the required temperature gets inside the refrigerator.

2.13 Brief Study of basic components of vapour compression refrigeration system (VCRS)

2.13.1 Compressor:

A compressor is that part in mechanical refrigeration system which sucks the refrigerant vapours at low temperature and at low pressure and compresses it to a lower volume at higher temperature and at higher pressure. Moreover , it creates the flow of refrigerant from one place to another. A Compressor consists of an arrangement in which an electric motor drives it. The compressor is located near the condenser.

There are mainly two types of compressor are used,

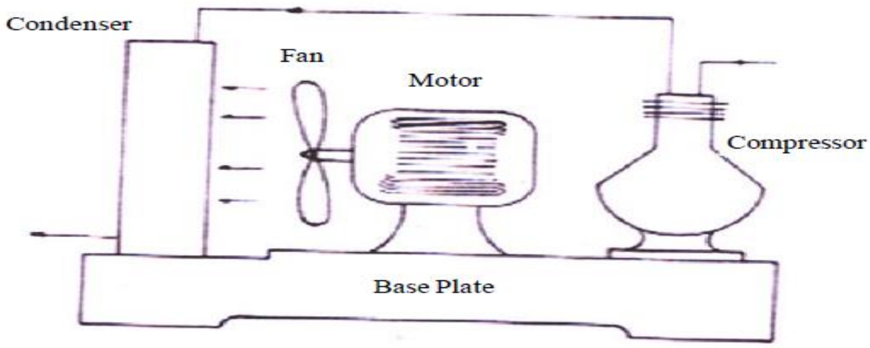
They are:

a) Open type compressor

b) Semi-hermetically sealed ,

c) Hermetically sealed compressor.

2.13.1.1 Open type Compressor:



Open type Compressor

An open type compressor is that in which the prime mover drives the compressor by means of belt. In such a unit the prime mover and compressor are separately serviceable. In this, the compressor is enclosed in crank case and crank shaft projects out through the compressor housing.

The projected end of crank shaft is connected directly or through the belt to the driving motor. The compressor and motor can be mounted on the same base plate. A seal must be used to prevent refrigerant leaking out or air from leaking in if the crank case pressure is lower than the atmospheric pressure.

These compressors are used in the plants employed for ice making, cold storage and food processing applications

2.13.1.2 Hermetically Sealed Compressor:

In ordinary compressor the crank shaft extends through compressor housing and it is connected to the driving motor . A seal must be provided at the place where the shaft comes out through the compressor housing . This is necessary to prevent the leakage of refrigerant outside or leakage of air inside. To avoid this problem , the compressor and motor are enclosed in one housing which known as Hermetically sealed compressor. These types of compressors are normally used for small capacity Refrigerating systems as house hold Refrigerator or small capacity coolers.

The main parts of a sealed unit are:

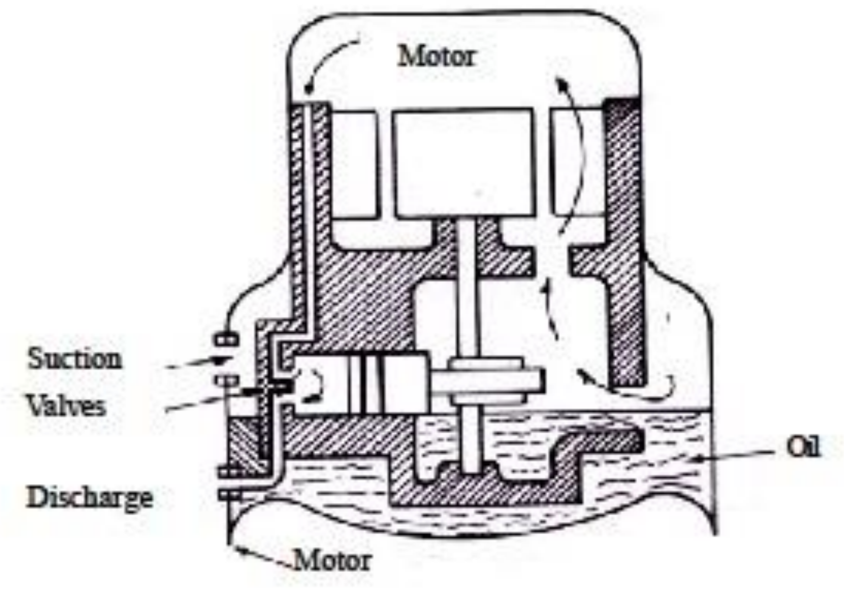
1. Electric motor,

2. Compressor,

3. Muffler,

4. Dome.

The Hermetically sealed Reciprocating compressor



Hermitically sealed Compressor

Advantages:

The advantages of hermetically sealed compressor s over ordinary type compressors as follows:

1. The leakage of refrigerant is completely avoided.
2. It is less noisy.
3. It requires less space.
4. The motor is cooled more efficiently.

Disadvantages:

1. Maintenance is not easy
2. The welded joints has to be broken or cut for reparing the compressor.

3. The pressure of moisture in the refrigerant may harm the winding of the motor.

4. A separate vaccum pump is required for evacuation and charging the refrigerant.

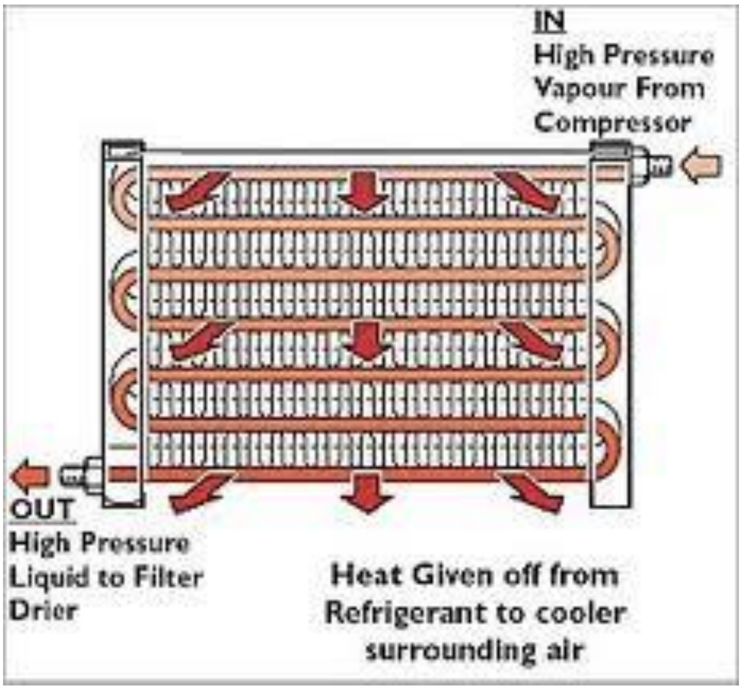
The motor and compressor assembly is mounted in the unit in such way that usually the motor is fitted on the top and the compressor on the bottom. But at present in a specially designed sealed unit,for keeping the motor cool, it is dipped in to the oil and bottom of the compressor is fitted at the top.The oil is forced to the compressor, through the shaft of the motor. Some times the motor and compressor and assembly is hung on the springs in the unit and sometimes it is press fitted.

As the motor is energised, it drives the compressor. The compressor sucks the low temperature and low pressure gas, compresses it into high temperature and high pressure gas and discharges it through the discharge line. Some of the examples of refrigeration machines in which sealed units
are used are:

1. Refrigerator,
2. Bottle cooler,
3. Window-type Air conditioner,
4. Water cooler.

2.13.2 Condenser:

condenser is an heat exchanger in which heat transfer takes place from high temperature vapour refrigerant to low temperature air or water which is used as cooling medium. Its purpose is to covert all the vapour refrigerant to liquid refrigerant delivered by the compressor.



Types of Condenser:

1.Air cooled condenser.

2.Water cooled condensers

3.Evaporative type condensers..

2.13.2.1 Air Cooled Condensers:

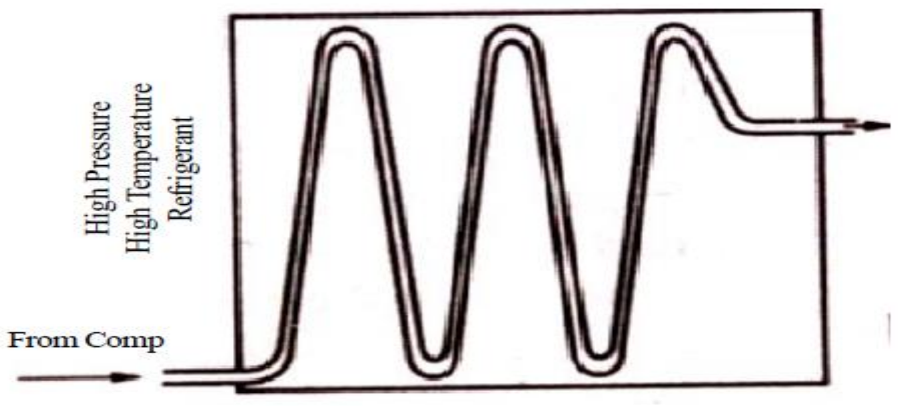
Air is used as the cooling medium in the air cooled condenser. Heat transfer takes place air convection around the condenser surface.

There are two types of air cooled condensers are used.

2.13.2.1.1 Natural air cooled condensers

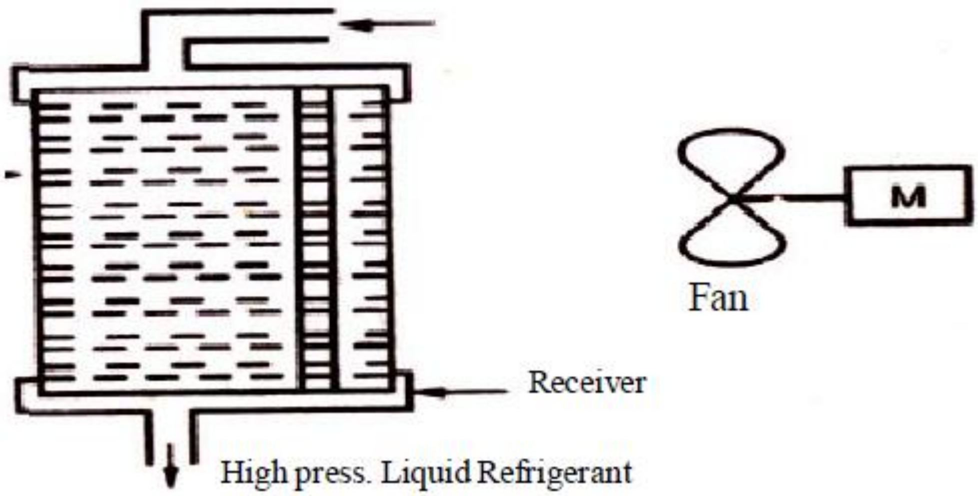
2.13.2.1.2 Forced air cooled condensers.

In the Natural air cooled condensers large condensing surface area is required as the circulated air quantity is less. This type of condensers are used in domestic refrigerator, deep freezer , etc., These are cooled by natural air or atmospheric air. These are provided at the back of the refrigerator.



Natural Convection Air Cooled Condenser

In the case of Forced air cooled condensers , air is circulated by means of a fan or blower. This type of condensers are compact in design and are relatively more efficient.



Forced Convection Air Cooled Condenser

These are commonly used for water coolers, bottle coolers and air conditioners.

Merits of Air Cooled Condensers:

1. Cheap due to simplicity of construction
2. Low maintenance cost.
3. No piping work involved.
4. Negligible corrosion effect.
5. Disposal of air is easier in comparison to disposal of water.
6. High flexibility.

Demerits of Air Cooled Condensers:

1. It is restricted to small capacity refrigeration units.
2. Rate of heat transfer is low.
3. Distribution of air on the condenser surface area is uneven.
4. Increase in ambient temperature causes reduction in the capacity Of the condensers.

The air cooled condensers are preferred under the following circumstances Minimum corrosion is the major requirement. Inadequate supply of cooling water Expensive means of water disposal.

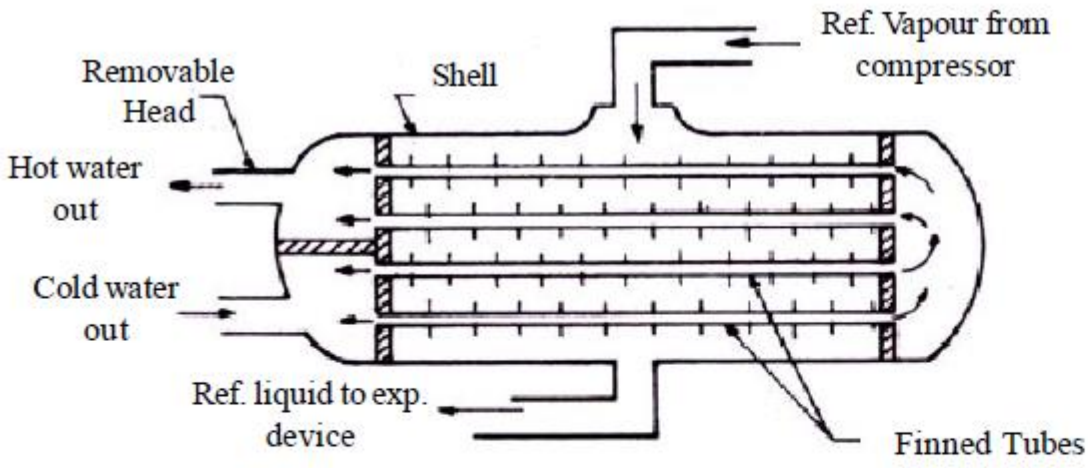
2.13.2.2 Water Cooled Condenser:

The condenser which cooled by water, is called water cooled condenser. These are always preferred where adequate supply of and inexpensive means of water disposal are available. These condensers are used in large capacity refrigerant plant such as, cold storage, ice plants and central air-conditioners.

There are three types of water cooled condensers:

2.13.2.2.1 Shell and Tube Condenser:

A shell and tube condenser consists of a cylindrical shell, in which a large number of parallel tubes are fitted and connected with tube sheets on both ends of these tubes. These tubes are made of steel or copper tubes. These tubes are generally finned to increase their surface area. The diameter of these tubes are 19mm,25mm,30mm etc.. The lengths are in between 1.5 m and 5.5m. These condensers have the capacity ranging from 2 ton to 1000 ton. Cooling water enters through the heads which are baffled to make one or more passes through the tubes. Refrigerant vapour from the compressor enters shell at the top and gives its heat to cooling water. After the completion of condensation , the liquid refrigerant flows down and remain in the lower part of the shell. Which act as a liquid receiver.



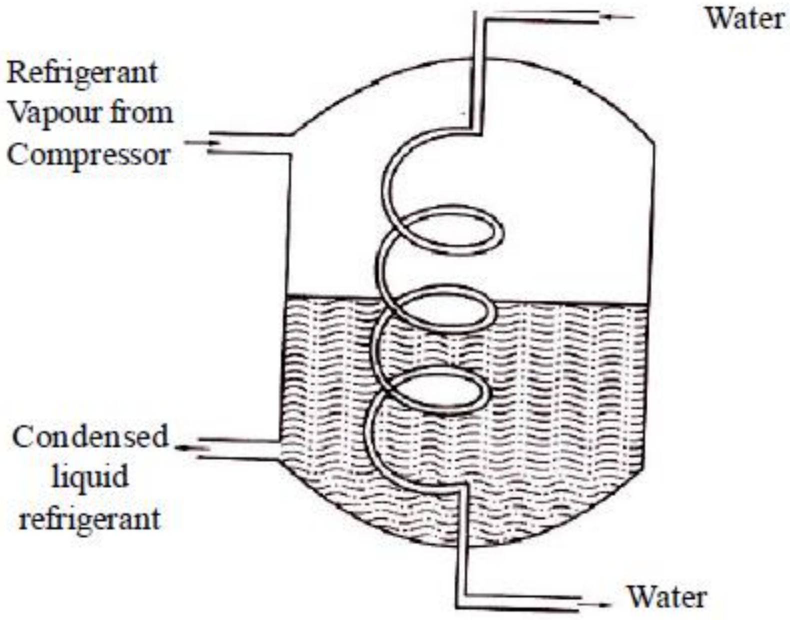
Shell and tube type condenser

2.13.2.2.2 Shell and coil type condenser:

Shell and coil type condenser are used for small tonnage low pressure units. It consists of shell that contains a coil for circulating the water . The shell ends are not removable and the water side of the coil may ;be cleaned with chemicals. In case of a coil leakage the entire coil must be replaced. These are preferable where clean water is available because its coil cannot be cleaned easily.

These can be cleaned only by circulating acids or other chemicals through them. In this, the water enters at the bottom and flows up through coil as shown in fig. Vapour refrigerant from the compressor enters at the top and flows down, the shell giving its heat to cool water. Refrigerant vapour gets

condensed and liquid refrigerant is collected at the bottom of the shell which acts also as receiver. These are used upto 50 ton capacity plants. Shell and coil type condenser



2.13.2.2.3 Double tube type Condenser:

A double type condenser has the condensing water tube in side the refrigerant tube. The refrigerant flows in the space between the tubes while water is pumped through inner tube. Water flows in the opposite direction to the refrigerant. The refrigerant vapour from the compressor enters at the top and flows downwards in the clearance space between the two tubes. As result of heat transfer from refrigerant to water, the refrigerant gets condensed. The liquid refrigerant leaves the condenser at the bottom. The scales formed in tubes are removed by chemical treatment. Since copper tubes cannot be used with ammonia. These are made of steel pipes for ammonia.

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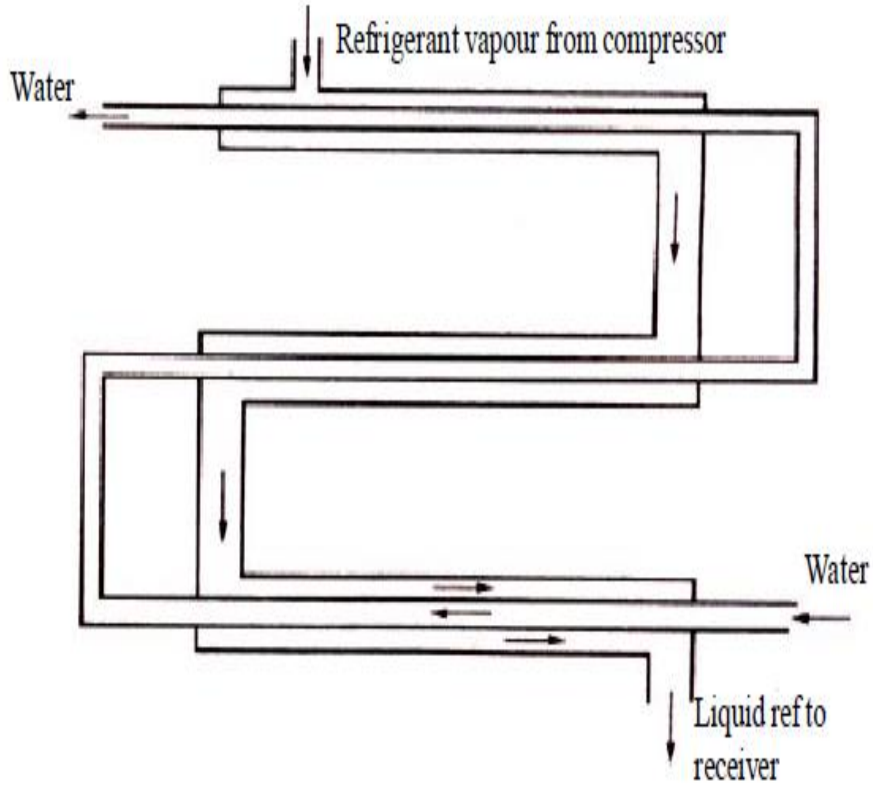


Double Tube type Condenser

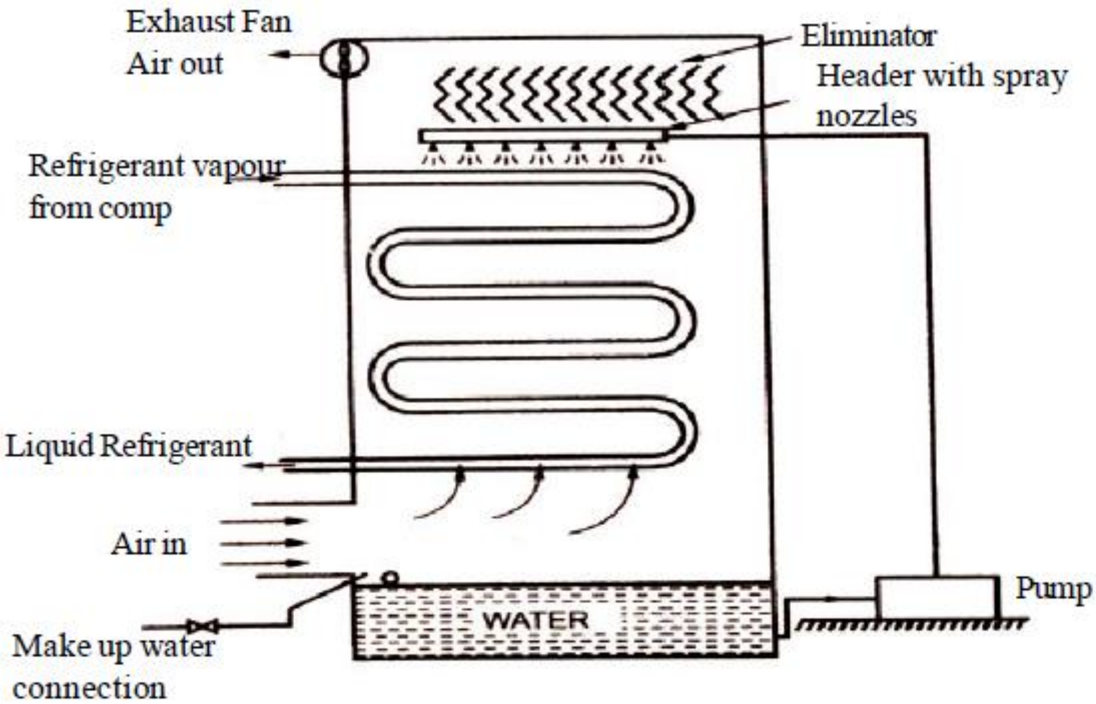
2.13.2.2.4 Evaporative Condenser:

The Evaporative condenser combines the function of the condenser and cooling tower. Its works on the principle of Evaporative cooling. The water evaporation when it comes in contact with the refrigerant flowing in the condensing coil. In this, both air and water are used as the cooling media.

The condensing coil are encased in galvanized steel cabinet. Water is sprayed over the condensing coil through which hot refrigerant vapour flowing. A pump is utilized for this purpose. An exhaust fan is fitted at the top of the condenser. It sucks air from side opening. Eliminators are provided in the condenser to prevent the escaping of water particles with air.

The air carries away the heat taken from refrigerant by the water vapour at about 3 to 5% of water circulated evaporates, make up water is admitted to tank through float operated valve. Water treatment should also be used to reduce the scale formation in the coil. The atmospheric air enters at the bottom and drawn over the coils by a fan. The air flowing up words through the water spray carries out the heat from the refrigerant .

These are used where there is scarcity of water, draining facilities are in adequate. The use of cooling tower is un economical. It is suitable for refrigerant plants above 100 ton capacity.



Evaporative Condenser

2.13.3 Evaporataor:

The Evaporator is a device in which the heat is removed from the substance to be cooled . It is part of the system in which the refrigerant evaporates or boils; It is the cooling unit and some times called the cooling coil Or freezing coil or liquid cooler .

Classification of Cooling Evaporator:

There are many types of evaporators used in the refrigeration and Air conditioning systems;

They may be classified:

2.13.3.1 **According to the refrigerant feed**

2.13.3.1.1 Flooded evaporator

2.13.3.1.2 Dry-Expansion evaporator

2.13.3.2 **According to the type of construction**

2.13.3.2.1 Bare tube coil evaporator

2.13.3.2.2 Finned tube evaporator

2.13.3.2.3 Plate evaporator

2.13.3.2.4 Shell and tube evaporator

2.13.3.2.5 Shell and coil

2.13.3.2.6 Tube- In-Tube evaporator or Double tube evaporator

2.13.3.3 **According to the mode of heat transfer**

2.13.3.3.1 Natural convection evaporator

2.13.3.3.2 Forced convection evaporator

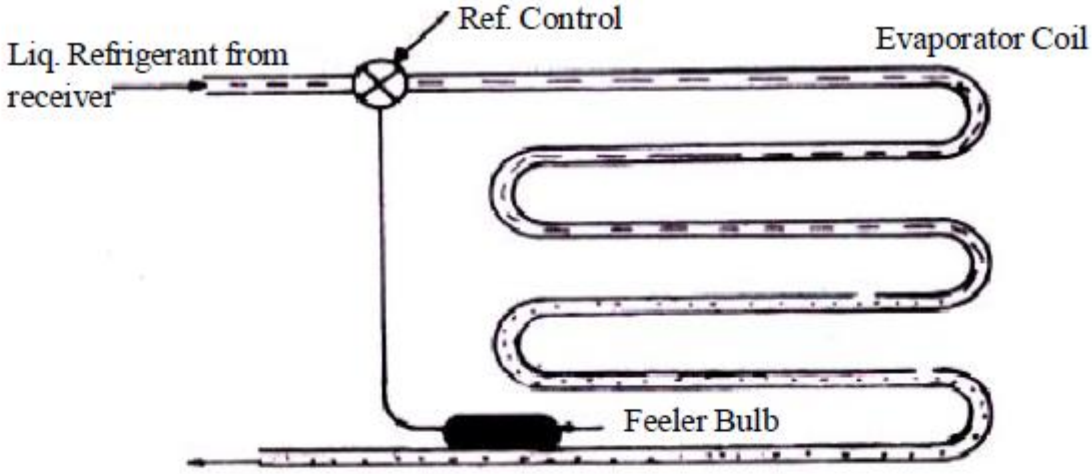
2.13.3.4 **According operative condition**

2.13.3.4.1 Frosting evaporator

2.13.3.4.2 De-Frosting evaporator.

a). Dry –Expansion Evaporation:

In this, the liquid refrigerant is fed by expansion valve. The refrigerant entered in to one end of the tube and the other end of tube is connected to suction line. The evaporator is filled with mixture of liquid and vapour refrigerant. As refrigerant passes through the evaporator, more and more liquid is vapourised. Thus, the refrigerant leaves the evaporator in dry state. A Feeder bulb is provided to control the flow of refrigerant in to the evaporator .

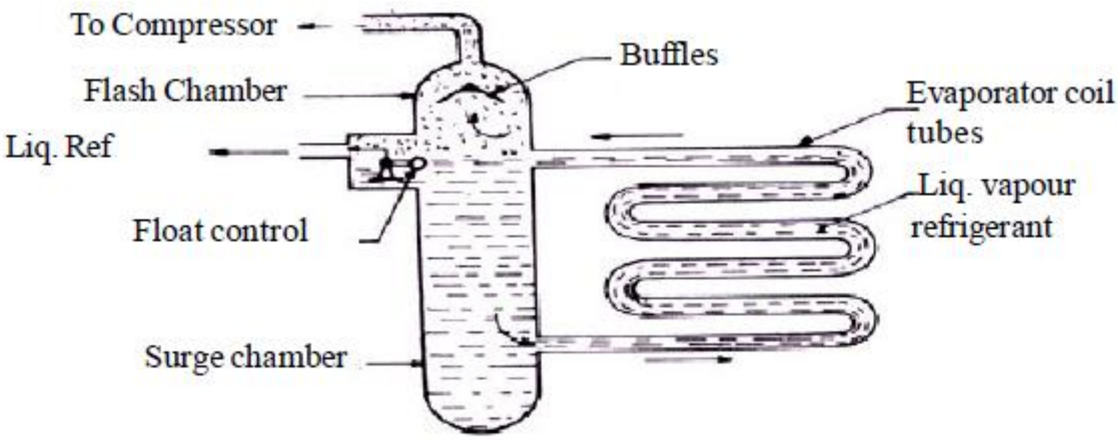


Dry - Expansion Evaporation

It is used in small capacity units of below 150 tons.

b). Flooded type Evaporator:

In a Flooded type evaporator a constant refrigerant liquid level is maintained. A float valve is used as throttling device which maintains a constant liquid levlel in the evaporator. It consists of a shell in to which the refrigerant liquid is fed through the float valve. The shell is connected to the top and bottom of the coil. The liquid flows from the bottom of the shell by gravity to coil tubes in which it evaporates by absorbing heat from the surrounding. The liquid vapour mixture from the coil returns to the shell. In the shell, the liquid and vapour are separated. The vapour is collected at the top of the shell (Flash chamber) from there it enters into the compressor through suction line. Flooded type evaporators provide rapid cooling and used in large capacity equipment .



Flooded type evaporator

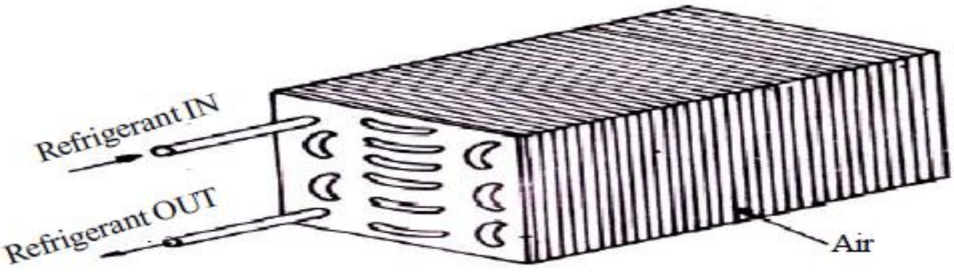
c). Bare tube Evaporator:

Bare tube evaporators are constructed of either steel pipe or copper tubing. Steel pipe is used for large evaporators and copper tube is used for small evaporator. Using Freon as refrigerant these are also used with secondary refrigerant as in the case of water chiller and ice making plants. This is shown in fig These are used where the temperature is maintained below 0C.

Bare tube evaporator

e). Finned Tube Evaporator:

Finned coils are bare tube coils upon which metal plates or fins are installed. Fins increase the surface area of the evaporator and there by improves effective cooling. The number of fins provided depends on the capacity of evaporator. These evaporators are mostly used in Air-Conditioning system.



Pinned tube evaporator

f). Plate Surface Evaporator:

surface area of evaporator and hence, higher rate of heat transfer from surrounding to the refrigerant. It is easily clean and defrosted manually. It is used in domestic Refrigerator or Freezes.

g). Shell and Tube Evaporator:

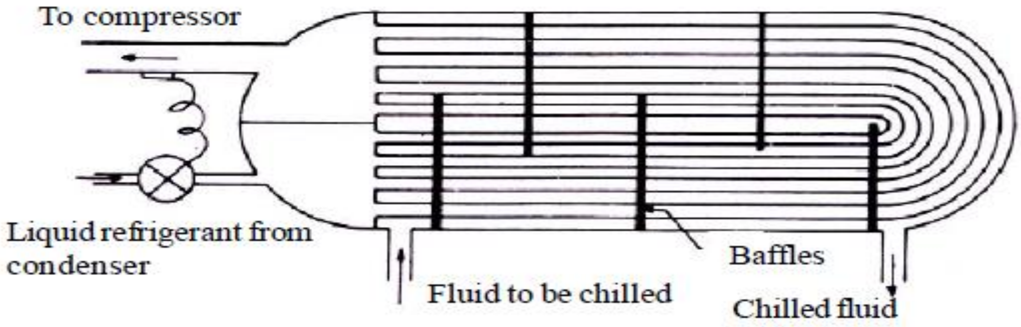
Shell and tube evaporator consists a steel cylindrical shell fitted with a large number of parallel tubes. These are used for chilling water or brine. These are mainly two types

1. Flooded shell and tube type
2. Non-Flooded shell and tube type.

h). Flooded Shell and Tube Evaporator:

In flooded shell and tube type evaporators, the fluid to be cooled flows through the tubes and refrigerant flows over the tubes. Liquid refrigerant absorb heat from water and evaporates completely. The dry refrigerant vapour is sucked in the compressor.

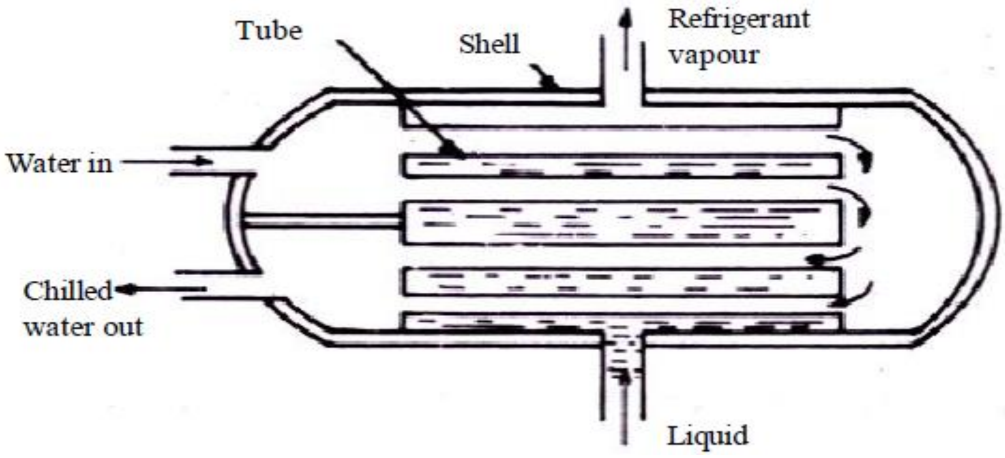
These are used for refrigerating units of capacity at about 100 ton.



Flooded Shell and Tube Evaporator

i). Non - Flooded Shell and Tube type Evaporator:

In Non-Flooded shell and tube evaporator, the refrigerant flows inside tubes and evaporates as it abstract heat from the fluid being cooled flows over the tubes as shown in fig. In this , the baffles are provided to improve the heat transfer.

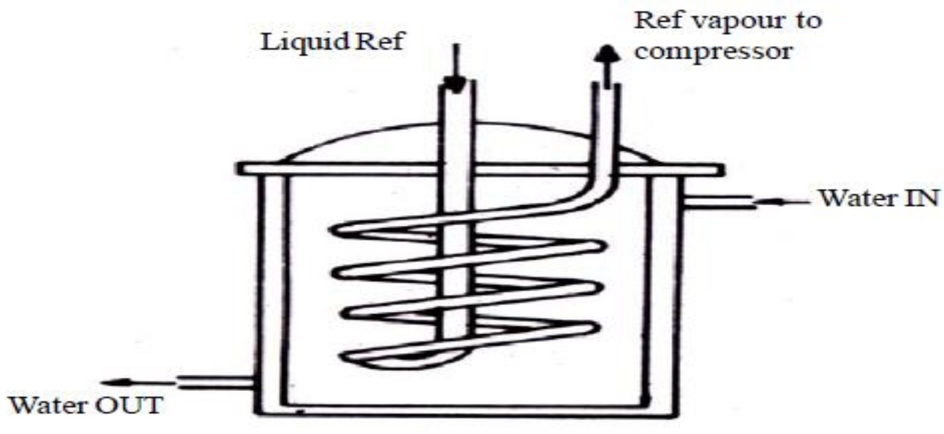


Non - Flooded Shell and Tube type Evaporator

These are used upto 50 ton capacity.

j). Shell and Coil Evaporator:

Shell and coil evaporator consists of shell and helical coil. The fluid to be cooled enters at the top and leaves the bottom of the shell. The refrigerant flows through the coil . The fluid to be cooled , comes in direct contact with coil. These are used in water cooler and small capacity units ranging from 2 to 10 ton capacity.

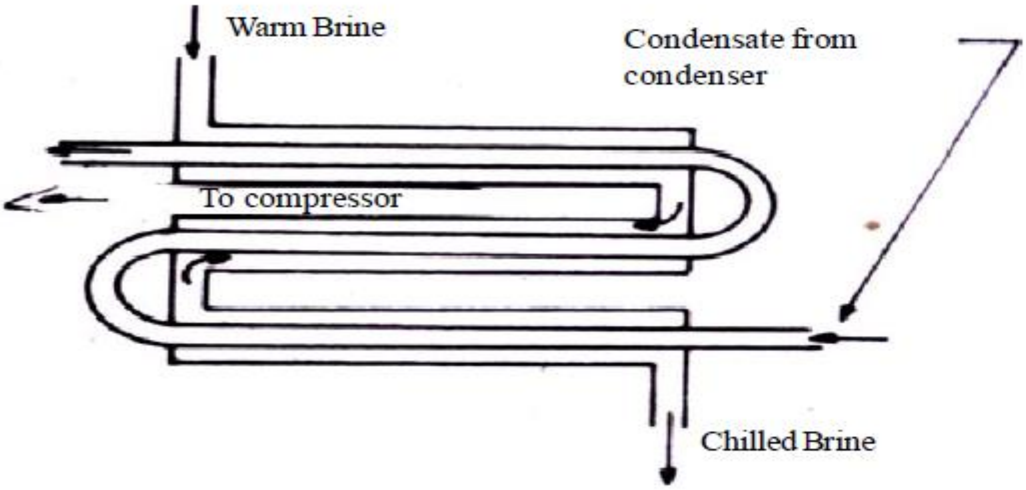


Shell and Coil Evaporator

k). Tube – in – Tube Evaporator:

These are called as double tube evaporators. It consists two concentric tubes. The fluid to be cooled flows through inner tube where as the refrigerant flows through the annual space between the two tubes. This arrangement improves the heat transfer. These are used in dairy, beverages

and oil plant



Shell and Coil Evaporator

1.11.4. Expansion Deveices or Valve:

Expansion device or valve is a dev ice which regulates or meters flow of liquid refrigerant to an evaporator. It also divides high pressure side from low pressure side of the system.

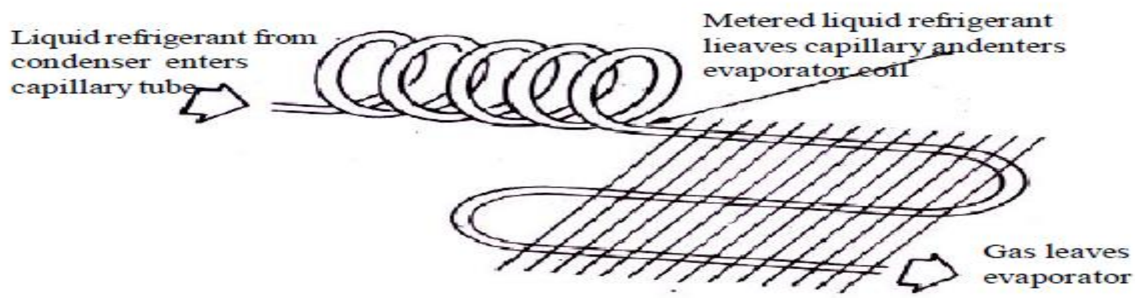
Functions:

It reduces the pressure of the refrigerant coming from condenser and temperature as per the requirement of system It regulates the flow of refrigerant as per the loan on the evaporator. The various types of evaporators are

a. Capillary tube
b. Pressure control or automatic expansion valve
c. Thermostatic expansion valve
d. High-side float valve
e. Low-Side float valve
f. Solenoid valve

2.13.4 Capillary Tube:

Capillary tube is a coil or length of fine tube that has a very small orifice usually 0.5 to 2.25 mm inside diameter and length is about 1 to 6 m. It is a constant restrict type expansion device,



Capillary tube

because the opening through which the refrigerant flow is constant. It controls the flow of refrigerant in to the evaporator. It is used with smaller hermitic units such as room Air-Conditioners and its application extends up to refrigerating capacity about 10 kw. The usual form of capillary tube installed in refrigerating plant is shown in Fig 2.20 One end of capillary tube is connected to filler at the outlet of the condenser. The other end is connected to evaporator. The capillary tube reduces the pressure of the refrigerant from high-side pressure to low-side pressure. Liquid refrigerant from condenser enters in to the capillary tubes and as it flow through the tube pressure drops due to friction.

The capillary tube replaces thermostatic expansion valve for small units such as Domestic Refrigerator, Room Air-Conditioner and deep Freezers

The advantages of capillary tubes are:

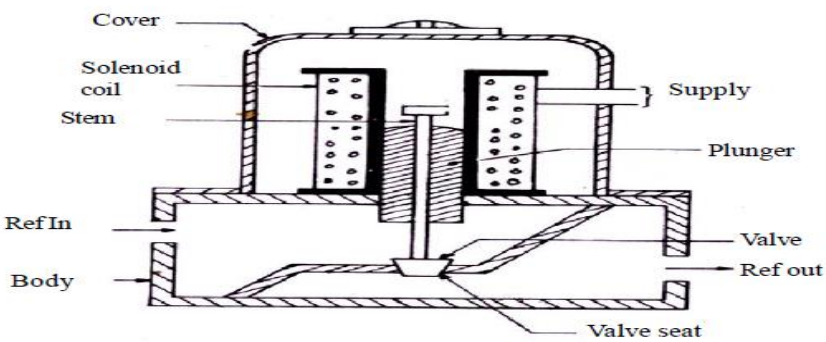
1. It is simple in construction and requires no maintenance When the compressor stops,
2. the refrigerant continues to flow from high pressure side to low pressure side unless pressure is equalized. This requires low starting torque to start the compressor so a low starting torque motor can be used with these unit.
3. No receiver is required for systems using this device.
4. Its cost is much less as compared to other devices.

Disadvantages:

The refrigerant must be free from moisture and dirt other wise it will choke the tube and stop the flow of refrigerant . It cannot be used with high fluctuating loads.

2.13.5 Solenoid Valve:

The solenoid valve is shut off valve that is actuated by a electromagnetic coil when the coil is energised .An armature or plunger placed inside the coil. A stem or pin attached to plunger open or close. When the coil energised by passing current through it , the magnetic field attracts the plunger up into the core of the coil which causes the opening of the valve. When the coil is deenergised due to break in the circuit, the plunger fall of its own weight and pin closes the valve. These valves fitted vertical and allows the fluid flow in one direction.



Solenoid Valve

Solenoid valve is installed in the liquid line just a head of the expansion valve. They are used to control the condensing fluid when ever solenoid valve is used in a system, it is essential that the strainer should be installed ahead of it to prevent the entry of any contaminants.

2.14 Refrigerants:

The refrigerant is a heat carrying medium which during their cycle in the refrigerant system absorb heat from a low temperature system and discard the heat so absorbed to a higher temperature system.

The natural ice and a mixture of ice and salt were the first refrigerants. In 1834, either, ammonia, sulphur dioxide, methyl chloride and carbon dioxide came into use as refrigerant in compression cycle refrigerant machines. Most of the early refrigerant materials have been discarded for safety reasons or for lack of chemicals or thermal stability. In the present days, many new refrigerant including halo-carbon compounds are used for air conditioning and refrigeration applications.

The suitability of a refrigerant for a certain application is determined by its physical, thermodynamic, chemical properties and by various practical factors. There is no one refrigerant which can be used for all types of applications. If one refrigerant has certain good advantages, it will have some disadvantages also, Hence, a refrigerant is chosen which has greater advantages and less disadvantages.

2.14.1 desirable properties of an ideal refrigerant:

We have discussed above that there is on ideal refrigerant. A refrigerant is said to be ideal if it has all of the followings properties :

1. Low boiling point.
2. High critical temperature.
3. High latent heat of vaporization.
4. Low specific volume of vapour.
5. Low specific volume of vapour.
6. Non-corrosive to metal.
7. Non-flammable and non-explosive
8. Non-toxic.

9. Low cost.
10. Easy to liquefy at moderate at pressure and temperature.
11. Easy of locating leaks by odder or suitable indicator.
12. Mixes well with oil.

The standard comparison of refrigerant, as used in the refrigeration industry, is based on an evaporating temperature of 15^0C and a condensing temperature of $+30^0$C.

2.15 Classification of refrigerants:

The refrigerant may, broadly, be classified into the following two groups:

1. Primary refrigerants and
2. Secondary refrigerants.

The refrigerant which directly take part in the refrigerant system are called primary refrigerants whereas the refrigerants which are first cooled by primary refrigerants and then used for cooling purpose, are known as secondary refrigerants.

The primary refrigerant are further classified into the following four groups :

1. Halo-carbon refrigerant.
2. Azeotrope refrigerants.
3. Inorganic refrigerants.
4. Hydro-carbon refrigerants.

1.11. Applications of refrigeration system:

- Central air conditioning
- Food storage
- Making of ice
- Ice-Cream plants
- Industrial applications
- Hospital operation theatre
- Research laboratories
- Computer rooms
- Storage and transportation of food stuff
- Cooling of concrete for special application like dams
- Production of Rocket fuels

3 FABRICATION

In vapor compression refrigerating system basically there are two heat exchangers. One is to absorb the heat which is done by evaporator and another is to remove heat absorbed by refrigerant in the evaporator and the heat of compression added in the compressor and condenses it back to liquid which is done by condenser.

This project focuses on heat rejection in the condenser this is only possible either by providing a fan or by extending the surfaces. The extended surfaces are called fins. The rate of heat rejection in the condenser depends upon the number of fins attached to the condenser. In the present domestic refrigerator copper material fins are used.

The performance of the condenser will also help to increase COP of the system as the sub cooling region incurred at the exit of the condenser. The performance of the condenser is also investigated by existing and modification condenser. In general domestic refrigerators have no fans at the condenser and hence extended surfaces like fins play a very vital role in the rejection of heat.

In order to know the performance characteristics of the vapor compression refrigerating system the temperature and pressure gauges are installed at each entry and exit of the component. Experiments are conducted on condenser having fins. Different types of tools are also used like snips to cut the fins to required sizes, tube cutter to cut the tubes and tube bender to bend the copper tube to the required angle.

Finally the domestic refrigerator is fabricated as for the requirement of the project. All the values of pressures and temperatures are tabulated. In order to know the performance characteristics of the vapour compression refrigeration system the temperature and pressure gauges are installed at each entry and exit of the components. Experiments are conducted on condenser with coil spacing of the condenser on a refrigerator of capacity 180liters. All the values of pressures and temperatures are tabulated.

3.1 Stages of fabrication:

2.1.1. Brazing process
2.1.2. Winding of copper tubes
2.1.3. Capillary connection
2.1.4. Dehydrator
2.1.5. Condenser connections
2.1.6. Compressor connections
2.1.7. Evaporator connections
2.1.8. Thermal insulation
2.1.9. Thermostat
2.1.10. Gas charging
2.1.11. Fabrication of cabinet
2.1.12. lubrication

3.1.1 Brazing Process:

It is process of joining metal pieces by means of hard solder. Brass is mainly the main constituent of this solder. The brazing solder used in modern practice is commercially known as spelter, which is mixture of Cu, Zn and Sn. The most important phenomenon in this that the pieces to be joined are heated instead of the bit.

3.1.2 Winding of Cu Tubes:

Once the internal container is repaired, it is soldered at its ends. Now 5/6" copper tubes of length 22 feet was wound a round the outer surface of the sheet metal internal container, with equal spacing between them. These "Cu" tubes were positioned in their place firmly and rigidly with the help of soldering at place. Now these assembly functions as our Evaporator and these coils are called as "Evaporator Coils."

Both the ends of the Cu tubes Viz, the top and bottom of the internal container, where left free or unwound the upper portion of the tube was taken below along the external surface of the container and finally taken out of the bottom of the plastic bucket through a small boring. The other end of the coil was connected to the accumulator which is placed in between the bottoms of the bucket and the container. Ten this end was also taken out of the same boring and connected to the capillary tubes.

3.1.3 Capillary Connection:

One end of the capillary was brazed inside the accumulator to prevent leakage. The total length used for the purpose was 12feet. Initially, some portion of the capillary was wound around the 5/16' tube coming out from the lop surface of the container. Then, this capillary is made in the from of a uniform coil and was suspended freely. This capillary tube acts as an expansion valve.

3.1.4 Dehydrator:

The dehydrator or the filter drier is located in the fluid line at the outlet end of the condenser. Its purpose is to filter, trap minute particles of foreign materials and absorb any moisture which may be in the system. Fine mesh screens filter out foreign particles and the desiccant absorbs the moisture. The one used in this refrigerator desiccants is silica gel (silicon dioxide).

3.1.5 Condenser Connections:

Now a small piece of copper tubes id again brazed to the free end of he filter drier, which is then connected to the condenser. The condenser used in this unit is of air cooled type. In this the tube is bent in the shape of U and placed in conjunction with the fins are responsible for holding the air in their gaps that extract heat from the hot refrigerant flowing in the tubes of the condenser.

The evaporator coils surrounding the internal container absorb the heat from the hot boy inside the container and this heat is taken by the refrigerant. This refrigerant which is ultimate passing through the condenser radiates heat to the atmosphere with help of the condenser fins.

In our unit the condenser is fixed to the rear side of the cabinet, facing the atmosphere air.

3.1.6 Compressor Connection:

The 5/16' copper tube of the evaporator oil is connected to one end the compressor with the help of brazing. The outgoing end of the compressor is brazed to the condenser to complete the circuit.

The compressor used in this case is reciprocating type sealed unit. The horsepower of the compressor is 1/6 HP. Compressor is used to establish a pressure difference and thus cause the refrigerant to flow from one part of the system to the other. At the same time the compressor raises the refrigerants pressure above the condensing pint.

At the temperature of the room air, so it will condense. It is this difference in pressure between the high low sides forces liquid refrigerant through the capillary tube an into the evaporator.

3.1.7 Thermal Insulation:

In any refrigeration process thermal insulation is necessary so that no heat is radiated out of the system thereby reducing its efficiency.

Since heat will always flow from a region of high temperature to a region of low temperature, there is always a continuos flow of heat into the refrigerated region from the warmer surroundings. The various types of the insulators used are –

1. Thermocoal
2. Glass Wool.

In this unit glass wool is used which was stuffed between the two surfaces of the plastic bucket and sheet-metal container. The glass wool is tightly packed by ramming heavily so that no air gap remains between the glass wool and hence provides maximum operating efficiency.

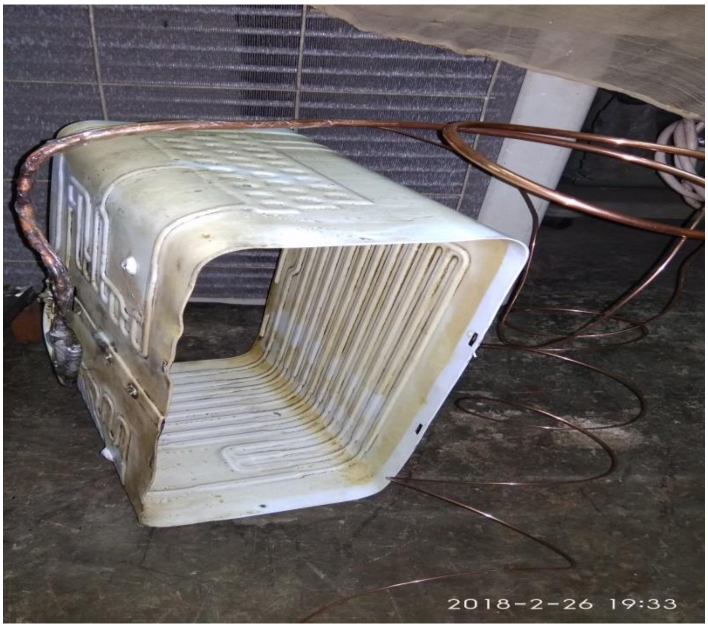
3.1.8 Thermostat:

This is a temperature controlled electrical switch located on the evaporator wall. It is fastened to the evaporator will with a clamp at the lower region of the internal container. When the sensing element mounted on the evaporator wall senses the temperature lower than the operating conditions then it sends the signal to the thermostat switch immediately breaks the circuit in the relay and thus gets Tripped Off. The thermostat switch is connected to the relay. The rely thermostat has the bimetal strips, which is responsible for the make and break of the circuit.

3.1.9 Gas Charging:

When the whole of the connections has been made then gas is charged with the help of the charging cylinder and the value is closed. The whole is now checked for the leakage by applying soap solution to the joints formed by brazing. Now when no leakage was there then the gas was filled. The amount of gas by weight was 15 ibs. The gas used for this was refrigerant 12 or Freon 12 (CCl_2F_2 – Dichloro- Difluro – Methane).

3.1.10 Fabrication Of Cabinet:



Wooden planks used to make the table of appropriate shape and size to accommodate the bucket in the bucket in the top tier while the other components in the basement.

The top plank is cut in the from of a round hole in which $2/3^{nd}$ of the bucket can go inside with remaining portion projecting outwards. It has got one more bottom plank supporting the compressor, the condenser and other accessories. The compressor is rigidly with the help of 4 bolts bolted to the base. This table-like structure is mounted on four wheel making the whole unit mobile.

3.1.11 Lubrication:

- Function of lubricating oil in a refrigeration system.
- Understand the importance of and dangers associated with draining oil
- Describe the properties of refrigerate oils
- Describe the purpose and functions of an oil separator
- List and explain three types of indirect oil cooling systems
- Identify major oil contaminants and described contamination control in refrigerant oils
- Explain three types of heat exchange in lubrication.

4 EXPERIMENTATION

3.1. Experimental setup:

The main loop of the system under study was composed of five basic components, i.e., a compressor, an evaporator, a condenser, capillary tubes and a liquid line filter–drier, as shown in Fig..There was used a system of a three-phase, 220 V, reciprocating compressor originally designed for R134a refrigerant. The input power of the compressor within the system varied between 230 and 300 W. The major ingredient of the compressor lubricant was mineral oils. A silica gel drier filter was used to absorb the moisture. Compact forced air cooled type condenser was used for their good heat transfer performances. Capillary tubes of different internal diameters were used to find the optimum operating points of the system. For minimizing the heat loss, the evaporator cabinet was well insulated by foam and thermocaol. The refrigerant used were R134a. Some other measuring and controlling components were used in the system, that were, an electrical switch, an,valve for controlling mass flow rate of the refrigerant, bourdon tube type pressure gauge and compound pressure gauge, 'J' type thermocouples and indicator and gas flow control valves.

4.1 Experimental data:

Refrigerant used: R-134a

Capacity of The Refrigerator: 180 liters

Compressor capacity: 0.125 H.P.

4.1.1 Condenser sizes:

Type of condenser: air cooled condenser

Diameter – 4.76 mm

Lenght-10.41m

Size of condenser as per standard specification is 11" x 10" x 3 Rows

4.1.2 Evaporator:

Length – 8.52 m

Diameter – 5.23 mm

4.1.3 Capillary:

Length - 2.428 m

Diameter - 0.8 mm

4.1.4 Pressure Gauge (0 to 300 PSI.):

Bourdon type pressure gauge which is used to get pressures at discharge point of compressor exit.

4.1.5 Compound Gauge. (-30 to 250 PSI.):

Bourdon type pressure gauge which shows both negative pressure (Vacuum) as well as positive pressure in the VCR system. This is used to measure pressures at suction point of compressor.

The pressure gauge in the high pressure line was installed just next to the filter/drier and just before the capillary tube. Another pressure gauge was installed in the low pressure return line to measure the pressure of the fluid returning back to the compressor.. A digital thermometer was used to determine the temperatures that were to be used in the analysis of the system. The readings of the temperature and pressure of VCR were plotted on the P-H chart and the corresponding enthalpies were noted down and from the values of the enthalpies obtained, the parameters such as refrigeration effect and the compressor work were determined. The carnot or ideal COP of the system was determined by using the temperature limits of the system and the actual COP of the VCR system was calculated by considering the ratio of the refrigeration effect and the compressor work obtained from the PH chart. Refrigerant used for the analysis of VCR system is R134a.

4.1.6 ¼ control valves:

one valve is placed between the compressor and condenser,another valve is between condenser and capillary tube. Which are used to control the flow rate of the refrigerant.

4.1.7 Filter:

Smart ¼ filter is placed between tyhe condenser and capillary tube. Which is used to filter the dust particles in refrigerant.

4.1.8 Guage adopters:

Adopters which are used to connect the pressure gauges to the circuit.

4.1.9 Thermometers:

Which are used to measure the temperature of the refrigerant at various sections.

4.2 Equipement details:

SI no	Name of the component	Quantity	Each component cost	Total cost
1	Compressor	1	1000	1000
2	180 lts Condenser	1	250	250
3	Capillary tube	1	110	110
4	Evaporator	1	600	600
5	Filter	1	280	280
6	¼ control valve	2	180	360
7	BPL relay valve	1	180	180
8	Guage adopters	3	40	120
9	¼ flatnut	8	28	224
10	¼ copper pipe 2ft	1	230	230
11	Pressure guage	2	375	750
12	Compound guage	1	400	450
13	Thermometer	2	275	550
14	Supporting stand	1	600	600
15	Foam	1	100	100
16	R-134a			250
17	Unions	2	50	100
			Total	**6454**

4.3 Experimental procedure:

The following procedure is adopted for experimental setup of the vapor compression refrigeration system

1. The domestic refrigerator is selected, working on vapor compression refrigeration system.

2. Pressure and temperature gauges are installed at each entry and exit of the components.

3. Flushing of the system is done by pressurized nitrogen gas.

4. R 134a refrigerant is charged in to the vapor compression refrigeration system by the following process:

5. Leakage tests are done by using soap solution, In order to further test the condenser and evaporator pressure and check purging daily for 12 hours and found that there is no leakages which required the absolutely the present investigation to carry out further experiment.

6. Switch on the refrigerator and when the evaporator temperature reaches -5 degrees centigreade is required to take the pressure and temperature readings at each section.

7. The performance of the system is investigated, with the help of temperature and pressure gauge readings

8.Now by changing the mass flow rate of the refrigerant by using valve arrangement.

9.By using the above proceedure we can calculate the required parameters.

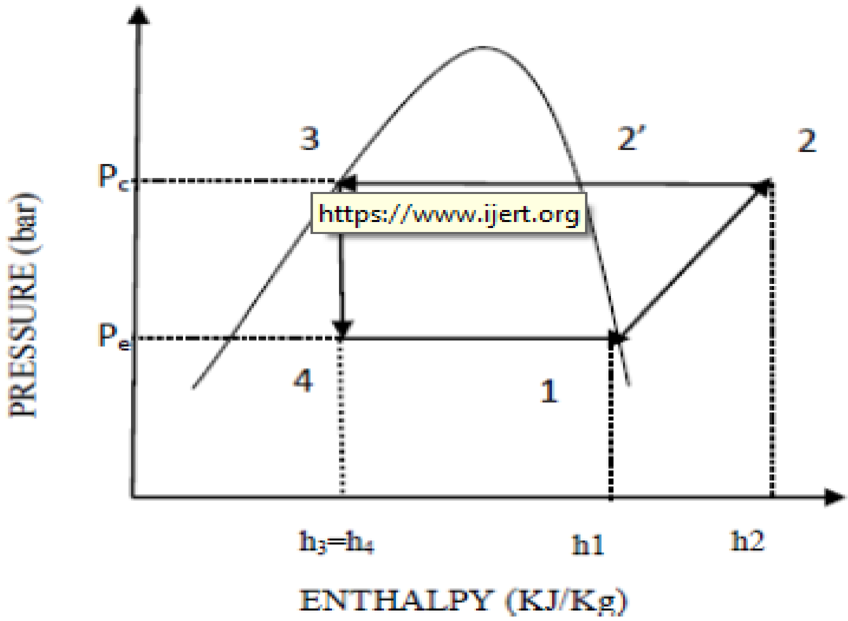
4.4 Experimentation Readings :

Repeating the experimentation using the same refrigerant R134a, by changing the valve arrangement and load, then observed readings are tabulated as follows:

Si no	Load(lts)	Time	Pressure(psi)				Temperature(*c)			
			P1	P2	P3	P4	T1	T2	T3	T4
1	**0**	20	16	170	170	16	12	59	37.3	-5
	0	16	14	195	190	14	13	58	39	-5
	0	15	12	180	180	12	14.2	58.6	45	-5
2	**1**	28	15	170	170	15	12	56	39.1	-5
	1	22	14	190	190	14	13.3	57	45.3	-5
	1	15	10	180	180	10	15.1	62	40	-5
3	**2**	30	16	175	170	16	14.3	61.1	44	-5
	2	20	13	190	190	13	15.3	60.3	47.1	-5
	2	14	10	180	180	10	13	57	44.6	-5
4	**3**	45	16	170	170	16	13.4	55	43.2	-5
	3	34	14	190	190	14	12.4	61	47.2	-5
	3	28	10	180	175	10	13.8	62	42.5	-5

5 CALCULATIONS

As shown in P-h diagram (Moeller diagram) for refrigeration cycle with four basic processes are frequently used in the analysis of vapour compression refrigeration cycle, process 1to 2 is compression, process 2 to 3 heat rejection in the condenser, process 3 to 4 expansion (Throttling) and process 4 to 1 is Evaporation i.e. heat absorbed in the evaporator. [5-6] described the performance of air conditioner components. The performance characteristics are can be computed for compressor work (Wc), Refrigeration Effect (QE) and Coefficient of Performance (COP) is expressed by the ratio of amount of heat taken by the cold body to the amount of work supplied by the compressor; this ratio is called Coefficient of performance.



Vapour compression refrigeration cycle on p-h diagram

The system performance is calculated as follows:

The work done during the isentropic compression per kg of refrigerant is given by

$Wc = m_r \times (h2 - h1)$ ------------------------------ (1)

The refrigerant effect or heat absorbed or extracted by the liquid-vapour refrigerant during evaporation per kg of refrigerant is given by

$QE = m_r \times (h1 - h4)$ ------------------------------(2)

The Coefficient of performance (C.O.P.) is the ratio of heat extracted in the refrigerator to work done on the refrigerator.

COP = Refrigeration Effect/ Work Done ------------- (3)

COP =H1−H4/h2−h1--- (4)

Pressure ratio =Pc/pe ------------------------------------ (5)

Energy Efficiency Ratio (EER) =3.5× COP ------------ (6)

Capacity of the system = 1 TR = 3.5 kW -------------- (7)

Heat rejected in the condenser = m_r ×(h2 –h3) ------------ (8)

Heat absorbed in the evaporator = m_r × (h1 – h4) --------- (9)

Where,

h1and h2 are enthalpies of refrigerant at the inlet and outlet of compressor (kJ/kg). h3= h4 are enthalpies of refrigerant at the inlet and outlet of expansion valve (kJ/kg). For the air conditioning system of 1 TR capacity, with the following operating conditions the Performance of the system can be computed as:

The operating conditions have been chosen for condenser temperature of and evaporator temperature for selected three different type's refrigerants (R134a) in vapour compression cycle. [7-9] explained the different studies of vapour compression cycle analysis.

By using P-h chart of R-134a the following properties are

Enthalpy of the refrigerant at entry to compressor is h1 = ...kj/kg

Enthalpy of the refrigerant at the at outlet of the compressor is h2 =....... kJ/kg

Enthalpy of refrigerant at outlet of the expansion valve h3 =h4=........ kJ/kg

Pressure at the in the evaporator =........bar

Pressure in the condenser = ...bar

Model calculations:

Temperatures:

Compressor suction temperature ,T 1= 12^{o}c

Compressor Discharge Temperature ,T2 = 59^{o}c

Condensing Temperature ,T3 = 37.3^{o}c

Evaporator Temperature ,T4 = -5

Pressure:

Compressor Suction pressure,P1= 16 psi

Compressor Discharge Pressure ,P2= 170 psi

Condensing Pressure,P3= 170 psi

Evaporator pressure, P4= 16 psi

Convert all the pressure in to Bar:

Conversion pressure Unit -1.psi = 0.069 bar

P1 =16 x 0.069 = 1.104 bar

P2 =170 x 0.069 = 11.73 bar

P3 = 170 x 0.069 = 11.730 bar

P4 = 16 x 0.069 = 1.104 bar

Formulas used:

Enthalpy at superheated condition:

H=hg+cp(Tsup-Tsat)

Enthalpy at saturated condition:

H=hg

Enthalpy at saturated liquid condition:

H=hf

From pressure enthalpy Chart for r 134a, enthalpy values at state points 1, 2, 3, 4. The state points are fixed using pressure and temperature and each point.

h 1 = 265.20 KJ/Kg

h2 = 289.92 KJ/Kg

h3 = 104.210 KJ/Kg

h4 = 104.210 KJ/Kg

Calculations Performance Parameters:

1. Net Refrigerating Effect (NRE) = (h1 – h4) = (265.20 – 104.210) = 160.99 KJ/Kg

2. Circulating rate to obtain one tone of Refrigeration, kg/min. m_r= 210/ NRE = 210/160.99=1.3044Kg/min

3. Heat of compression = (h2 – h1)= (289.92 – 265.20)= 24.71 KJ/Kg

4. Heat Equivalent of work of compression = m_r x (h2 – h1) = 1.304 x (24.71)

=32.23 kJ/min

5. Compressor power =(32.23 /60)=0.5372 kW

6. Coefficient of performance (**COP)** =Net refrigerating/EffectHeat of Compression

=(160.99/24.71)=**6.51**

7. Heat rejected in condenser = (h2 –h3) = (289.92-104.21) =185.71 kj/kg

8. Heat rejection Rate = (210/160.99) x 185.71 =244.24 kj/min

9. Pressure Ratio=Pd/Ps =170/16=10.625

6 RESULTS AND DISCUSSION

the performance parameters for all the values are calculated and tabulated as follows:

Parameter(lts)	**0**	**0**	**0**	**1**	**1**	**1**
Compressor suction temperature,T1(°C)	12	13	14.2	12	13.3	15.1
Compressor discharge temperature,T2(°C)	59	58	58.6	56	57	62
Condensing temperature,T3(°C)	37.3	39	45	39.1	55.3	40
Evaporator temperature,T4(°C)	-5	-5	-5	-5	-5	-5
Compressor suction pressure,P1(psi)	16	14	12	15	14	10
Compressor discharge pressure,P2(psi)	170	190	180	170	190	180
Condenser pressure,P3(psi)	170	195	180	170	190	180
Evaporator pressure,P4(psi)	16	14	12	15	14	10
Enthalpy,h1 (kJ/kg)	265.20	264.1	264	263.52	262.84	266.08
Enthalpy,h2 (kJ/kg)	289.92	286.27	287.12	287.07	287.46	292.31
Enthalpy,h3 (kJ/kg)	104.21	106.74	119.78	114.8	117.8	109.6
Enthalpy,h4 (kJ/kg)	104.21	106.74	119.78	114.8	117.8	109.6

Load(lts)	0	0	0	1	1	1
Refrigeration effect(kj/kg)	160.99	157.26	144.22	148	144.2	156.48
Circulating rate to obtain one tone of Refrigeration(mr) (kj/min)	1.304	1.335	1.456	1.4185	1.45	1.342
Heat of compression(kj/kg)	24.71	23.1	23.125	23.55	25.46	26.23
Heat Equivalent of work of compression(kj/min)	32.23	30.713	33.67	33.425	37.07	35.21
Compressor power per ton of refrigeration(kw)	0.5372	0.511	0.56	0.5561	0.61	0.586
Compressor power Coefficient of performance (COP	6.51	6.837	6.23	6.28	5.66	5.96
Heat rejected in condenser(kj/kg)	185.71	179.53	167.34	148.64	144.2	182.53
Pressure Ratio	10.625	13.92	15	11.33	13.57	18

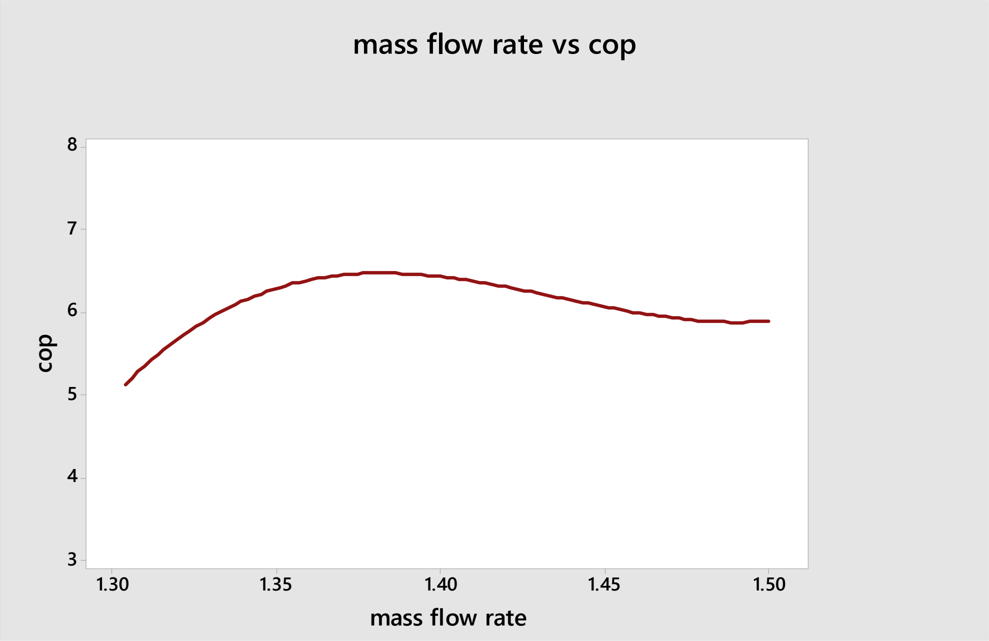
Load(lts)	**2**	**2**	**2**	**3**	**3**	**3**
Compressor suction temperature,T1(°C)	14.3	15.3	30	13.4	12.4	13.78
Compressor discharge temperature,T2(°C)	61.1	60.3	57	55	61	62
Condensing temperature,T3(°C)	44	47.1	44.6	43.2	47.2	42.5
Evaporator temperature,T4(°C)	-5	-5	-5	-5	-5	-5
Compressor suction pressure,P1(psi)	16	13	10	16	14	10
Compressor discharge pressure,P2(psi)	175	190	180	170	190	1750
Condenser pressure,P3(psi)	170	190	180	170	190	180
Evaporator pressure,P4(psi)	16	13	10	16	14	10
Enthalpy,h1 (kJ/kg)	261.12	266.39	264.43	260.73	261.6	267.57
Enthalpy,h2 (kJ/kg)	291.49	288.24	285.93	288.31	287.57	291.25
Enthalpy,h3 (kJ/kg)	116.38	119.58	118.64	114.48	121.5	112.98
Enthalpy,h4 (kJ/kg)	116.38	119.58	118.64	114.48	121.5	112.98

Parameter(lts)	2	2	2	3	3	3
Refrigeration effect(kj/kg)	144.74	146.81	146.1	146	138.01	154.59
Circulating rate to obtain one tone of Refrigeration(kj/min)	1.45	1.43	1.45	1.435	1.51	1.36
Heat of compression(kj/kg)	30.37	21.85	20.57	29.21	27	23.43
Heat Equivalent of work of compression (Kj/min)	44.53	31.25	31.25	42.01	40.9	31.9
Compressor power per ton of refrigeration(kw)	0.73	0.52	0.5442	0.7	0.68	0.53
Compressor power Coefficient of performance (COP	4.76	6.71	7.019	5.034	5.11	6.49
Heat rejected in condenser(kj/kg)	176.9	168.66	165	173.73	166	178.27
Pressure Ratio	10.625	14.615	18	10.625	13.5	18

Results:

Effect of coefficient of performance with mass flow rate of refrigerant for one ton of refrigeration:

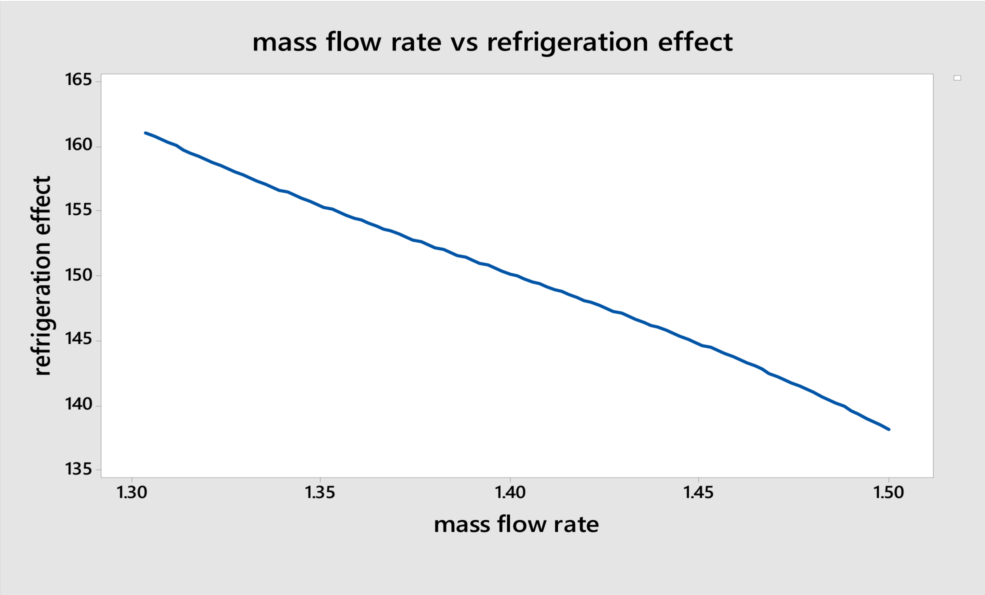
coefficient of performance of a Vapour compression refrigeration system with refrigerant R-134a is slightly decreases with increase of mass flow rate per one ton of refrigeration.the variation of coefficient of performance with mass flow rate as shown in graph-1.



Graph-1

Effect of refrigeration effect with mass flow rate of one to of refrigeration:

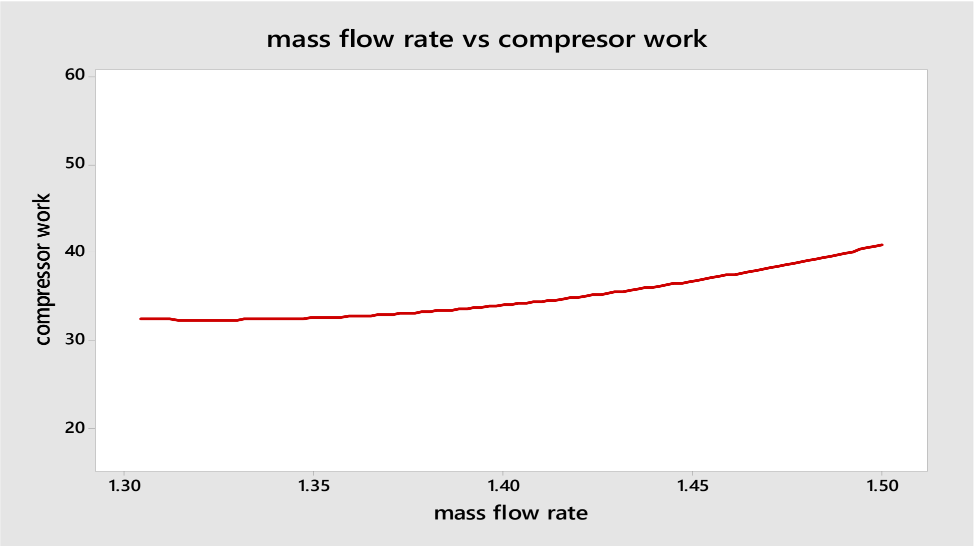
Refrigeration effect of a Vapour compression refrigeration system with refrigerant R-134a is decreases with increase of mass flow rate per one ton of refrigeration.the variation of refrigeration effect with mass flow rate as shown in graph-2.



Graph-2

Effect of compressor work with mass flow rate for one ton of refrigeration:

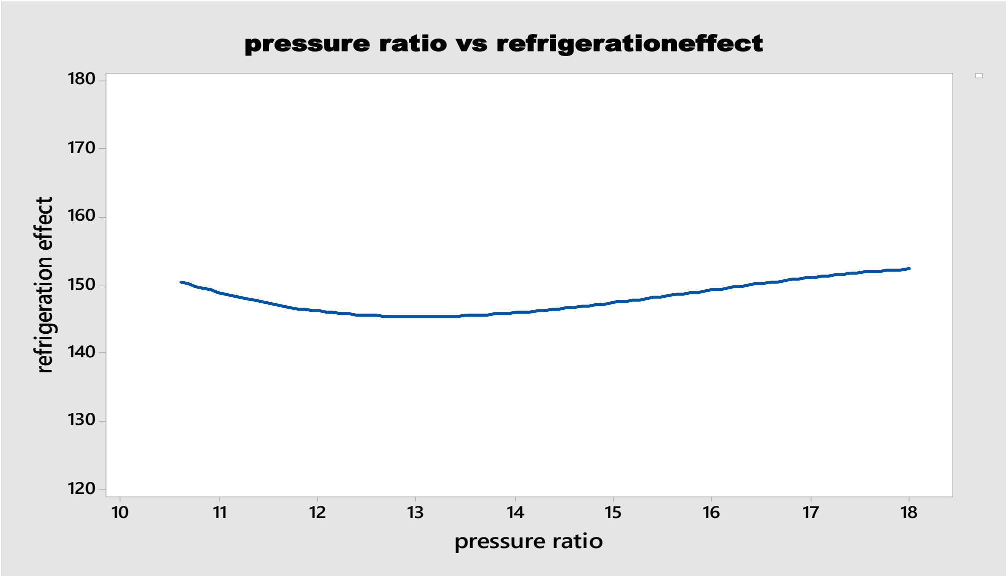
Compressor work of a the system is increase with mass flow rate.the variation in compressor work for different mass flow rates is shown in geaph-3.



Graph-3

Effect of refrigeration effect with pressure ratio:

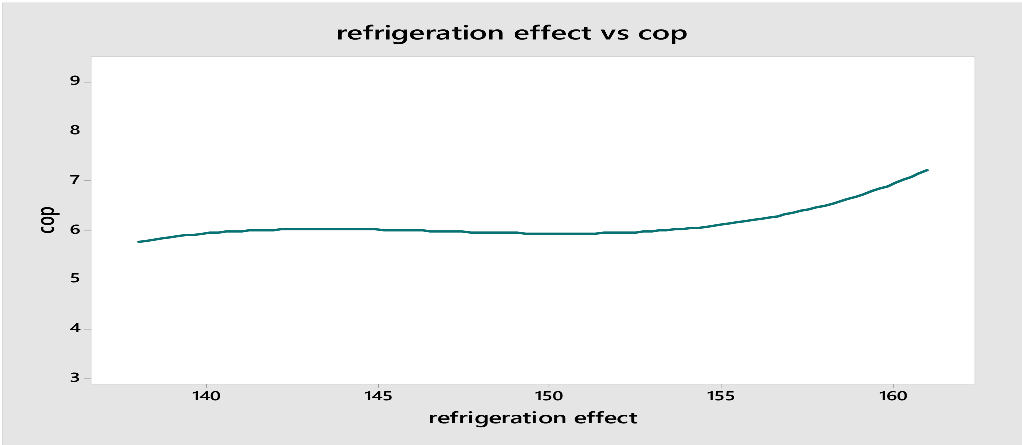
Refrigeration effect of the vapour compressor refrigeration system with r-134a as refrigerant is increase with increase of pressure ratio.the variation in refrigeration effect with different pressure ratios is shown in graph-4.



Graph-4

Effect of coefficient of performance with refrigeration effect:

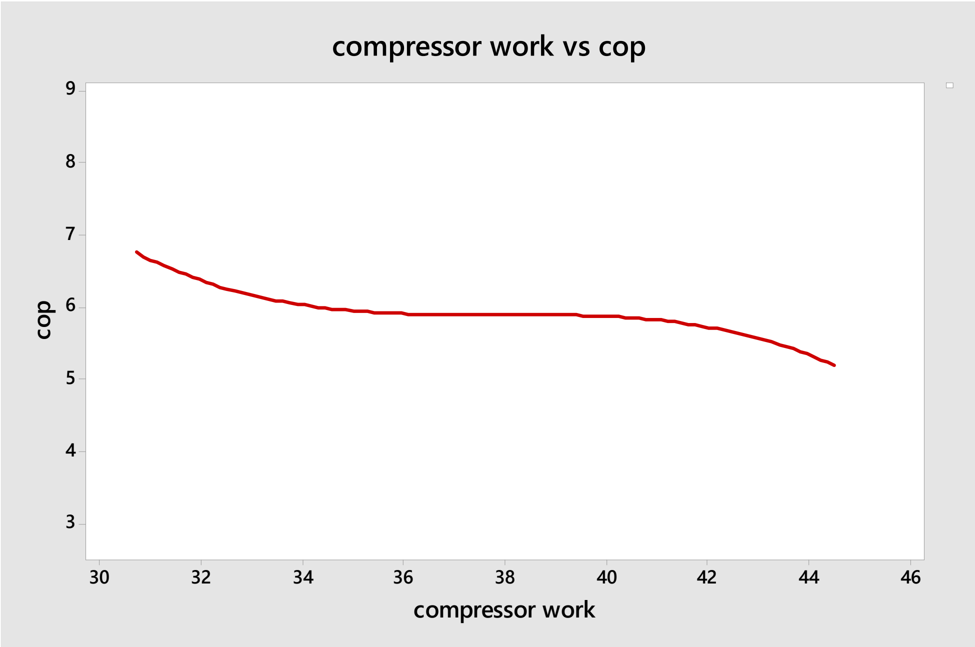
Coefficient of performance of a refrigeration system is the ratio of refrigeration effect to the compressor work so that if increase of refrigeration effect then the coefficient of performance will increase. In the present work the effect of coefficient of performance of a refrigeration system with increase of refrigeration effect is shown in graph-5. Observed that coefficient of performance is increases with increase of refrigeration effect.



Graph-5

Effect of coefficient of performance with compressor work:

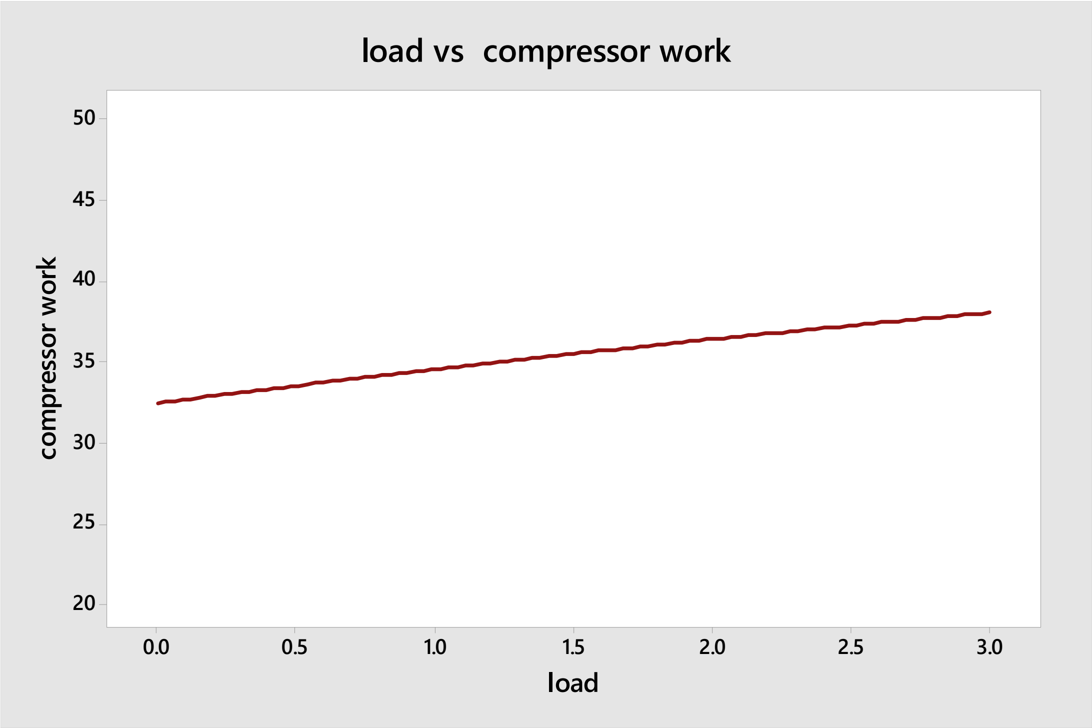
Coefficient of performance of a refrigeration system is the ratio of refrigeration effect to the compressor work so that if increase of refrigeration effect then the coefficient of performance will decrease. In the present work the effect of coefficient of performance of a refrigeration system with increase of compression work is shown in graph-6. Observed that coefficient of performance is decreases with increase of compressor work.



Graph-6

Effect of compressor work with load:

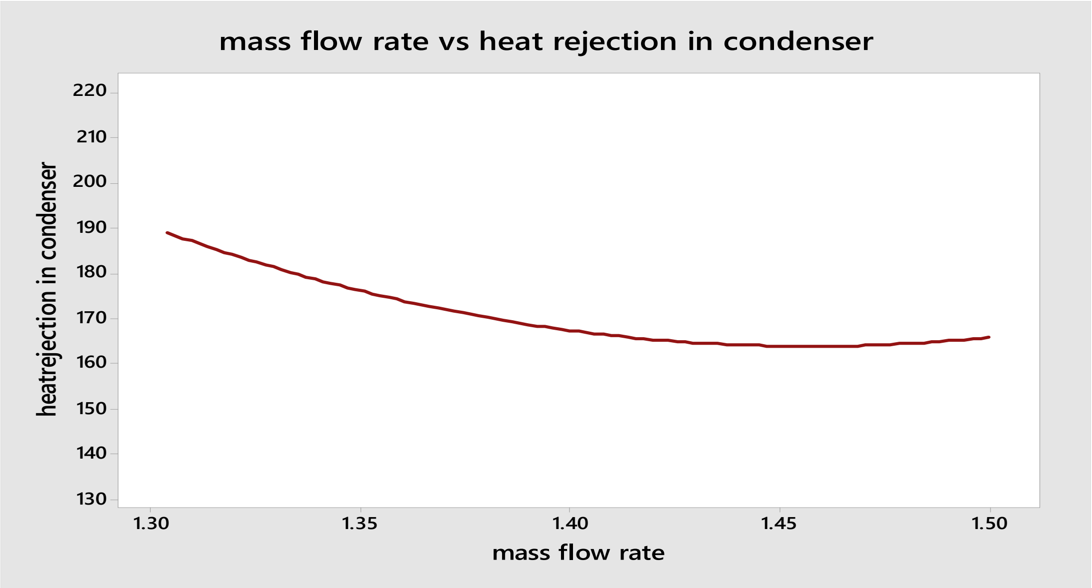
In the present work The variation of compressor work with load is shown in graph-7.observed that compressor work will increase with increase of load.



Graph-7

Effect of heat rejection in condenser with mass flow rate:

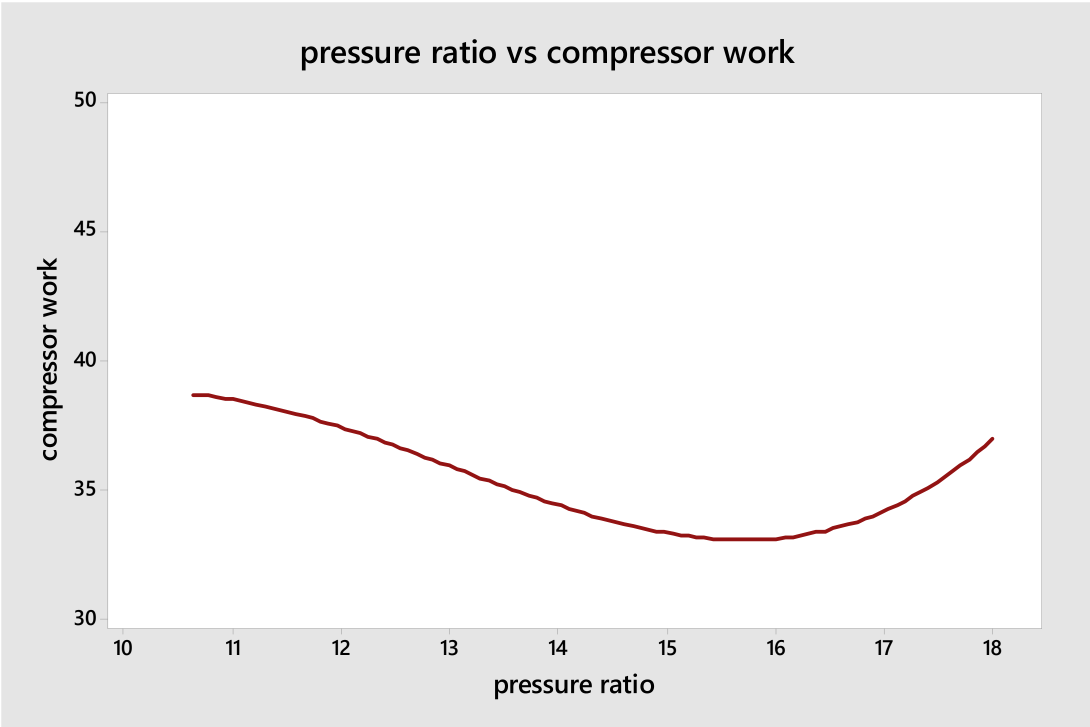
In the present work the effect of heat rejection with incease of mass flow rate is shown in graph-8.observed that with increase of mass flow rate of the system per ton of refrigeration the heat rejection in the condenser will slightly decreases. The variation of heat rejection in condenser with defferent mass flow rates has been shown in graph-8.



Graph-8

Effect of compressor work with pressure ratio:

In the present work The variation of compressor work with different pressure ratios is shown in graph-9.observed that compressor work will increase with increase of pressure ratio.in low pressure ratio the compressor work will be high further increasing the pressure ratio the compressor work will decreases upto some extent if further increase the pressure ratio then the compressor work will increases



Graph-9

7 CONCLUSION

In the present work fabrication of a vapour compression refrigeration system and experimental investigation is carried out to investigate the performance of vapour compression refrigeration system of a domestic refrigerator of 170 liters capacity, with R-134a as refrigerant with different mass flow rates and different loads..

After conducting the experiments, the following conclusions are drawn.

- coefficient of performance of a vapour compression refrigeration system decreases with increase of mass flow rate per one ton of refrigeration.coeffient of performance will increase for mass flow rate up to 1.4 kj/min if further increase in mass flow rate will decrease the coefficient of performance.
- Refrigeration effect of a Vapour compression refrigeration system is decreases with increase of mass flow rate per one ton of refrigeration.
- Compressor work of a the system is increase with increase of mass flow rate.
- Refrigeration effect of the vapour compressor refrigeration system with r-134a as refrigerant is increase with increase of pressure ratio.
- The coefficient of performance of a refrigeration system with increase of refrigeration effect.
- coefficient of performance is decreases with increase of compressor work.
- compressor work will increase with increase of load.
- heat rejection in the condenser will slightly decreases with incease of mass flow rate of the refrigerant per ton of refrigeration
- compressor work will increase with increase of pressure ratio.in low pressure ratio the compressor work will be high further increasing the pressure ratio the compressor work will decreases upto some extent if further increase the pressure ratio then the compressor work will increases.

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